THE GRASSLAND AND FODDER RESOURCES OF INDIA

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THE GRASSLAND AND FODDER RESOURCES OF INDIA

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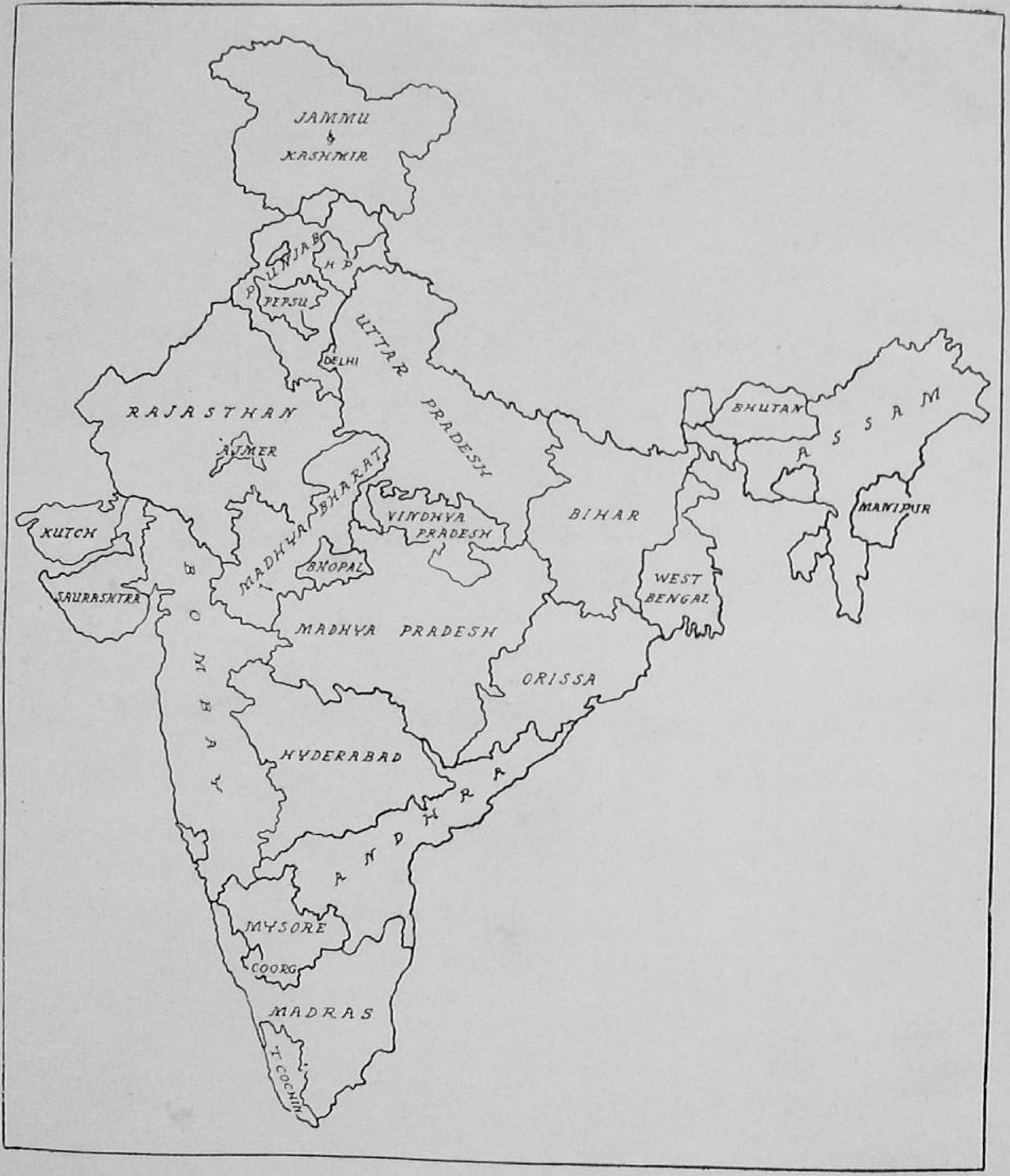

Fig. 1
Political map of India (showing Andhra). Before reorganization of States in 1956.

CHAPTER I

INTRODUCTION

FOR many years it has been recognized that the grazing and fodder resources of India have become inadequate to meet the needs of the livestock population. Attention has been drawn to the problem both by Indian workers and also by numerous visiting scientists in the fields of agriculture, animal husbandry, dairy production and soil conservation. Although it has been generally agreed that there is something radically wrong with the present situation, no attempt has so far been made to review the past and present knowledge and experience on the nature and utilization of the grazing and fodder resources as a whole, and to relate this information to other branches of land utilization, agriculture, animal husbandry and forestry in India.

This has been the objective of the team of Indian workers which has been associated with the F. A. O. specialist assigned to study the problem and to suggest measures of research and practical demonstration which might be adopted. The study has been made on the widest possible basis, as it has been recognized that grazing and fodder resources are not only of interest *per se* but also that their development and utilization may be the key to many problems in related fields of land use and agricultural production. Grazing and fodder resources contribute to the better feeding of livestock and so to better human nutrition and greater efficiency from the working animals ; they also play an important role in the maintenance of soil fertility on cultivated land, in the correct management of forests, and in the conservation of soil and water by a protective plant cover.

The first step in a review of this type is to consider the nature of the demand in relation to the actual and potential supply. It is most difficult to construct the demand side of the balance sheet in India. Grazing and fodder resources should ideally be adjusted to the number and type of livestock ; dairy animals require the highest available form of fodder production with continuity of supply of high quality green and other feeds month by month throughout the year; less demanding types of livestock such as sheep and goats are able to exist and produce on a lower plane of nutrition with considerable seasonal variations in quantity and quality.

In considering the demand in relation to the available resources, we refer repeatedly to certain calculations and estimations which have been made on an all-India basis and which are used to indicate the approximate degree of deficiency in grazing and fodder resources. Such figures must be liable to very considerable errors and should be replaced by data obtained on a statistical sampling basis. It should be possible to select a sample of villages in, say, Uttar Pradesh, to obtain all the necessary data down to the smallest detail, to record the result as representative of all or most villages in the State, and to plan accordingly. In a small unit like Delhi State, it has been possible to obtain the data essential for planned development from all the 320 villages in the State, but data reliable within about 10 or 15 per cent should also be obtainable from the larger States by intelligent use of the sampling method.

Most of the work on livestock improvement in India, as in many other countries, has been directed towards breeding and health, while feeding, without which neither of these can be fully effective, is neglected. Because of the critical situation, every conceivable type of grazing and fodder resource must be utilized in India. It is necessary to consider the grazing land in all its forms, from the tall jungle grassland of the Terai to the scanty vegetative cover of the semi arid tracts of Rajasthan. To this resource,so variable in accessibility, quantity, quality, and possibility of adequate utilization, must be added the fodders and the feeds, the seriously inadequate high quality fodder crops, the crop residues which are the main basis of hand-feeding in India, the tree leaves, seeds and fruits which are or might be used to supplement the supply of nutriment in critical seasons or years.

In order to be able to indicate the economic potentialities of India's grasslands, it is necessary first to understand their ecological position in the natural vegetation. It is generally agreed that there would probably be no grasslands in India were it not for the centuries-old practices of tree felling and lopping, shifting cultivation, burning and grazing. These biotic factors have operated in varying combinations and intensities to produce relatively stable types of grassland, which are, however, seral in nature, merely stages in regression of an original forest type of vegetation.

The elimination even for short periods of the biotic factors from these types of seral grasslands has the effect of starting progression towards the climax. If an area is badly denuded, closure should lead within three or four years to the regeneration of a cover of palatable and unpalatable grasses. If this vegetation is not

then utilized by controlled grazing and cutting, it may deteriorate in quality due to the appearance of less desirable grasses and shrubs which are, however, higher in the ecological progression up to the forest type. There are indications that the highest form of grass cover before the forest succession begins is not always the most valuable economically, one of the lower stages being more desirable from a grazing point of view.

A great deal of work has been done on the taxonomy of Indian grass species, but so far the scattered information on the ecological relationships of the many and varied types of grassland vegetation has not been fully studied and reviewed. Present indications are that there are at least 30 or 40 and probably more types of grassland in India, having regard to the species which are dominant in each. Seth (1955) recognizes fourteen types in Uttar Pradesh and Kumar defines at least ten types in Bombay State. It appears, however, that these types of grassland can be classified in some eight to ten groups, in which they represent seral stages under recognizable major grassland types.

Most of the existing grasslands near centres of population have been so misused that their plant associations are very low in the ecological succession. The lower they are, the less effective are they in providing good grazing and in protecting the soil. It is the objective of the Grassland Survey initiated by the Government of India to be able to recognize these regressive types and later by observation and experimentation to indicate the improved types of grassland which might be obtained with correct ecological management. The Grassland Survey will also obtain data of the yield from different associations and, therefore, of their respective carrying capacities. Ultimately, therefore, it will be possible to state the number of livestock that any particular area of village or forest grassland can maintain during the post-monsoon grazing season of four or five months without causing deterioration in the grass cover or in the capacity of that cover to conserve soil and water.

India is not a year-round grazing country, although this is the normal practice; in most regions, the effective grazing season does not extend for more than four or five months of the year. Even during these months, the nutritive value of the herbage at its best is such that it cannot always provide both a maintenance and production ration for high-quality livestock. If a proper standard of nutrition is to be maintained, livestock must be provided with cultivated fodders in the green or conserved state, concentrates and other feeds to supplement the

grazing during the grazing season and to replace it for some seven or eight months of the year. Although fodder species are available for inclusion in farming systems in most, if not all parts of India, they still represent a very small percentage of the total area under cultivated crops. Cereal straws (*bhusa*), *juar* stalks (*kadbi*) and other crop residues provide the main fodders. Because of the poor quality of the natural herbage in India and the great deficiency in high-protein cultivated fodder crops, concentrates acquire great importance, but they too are in very short supply and expensive in relation to the average productivity of Indian livestock.

There are three distinct types and standards of animal husbandry in India. The best is to be found in the large private, Government and Military farms, where the pasture and fodder calendar is correctly designed and followed, and livestock are maintained on an adequate plane of nutrition throughout the year. The second type is that practised in the villages and which, therefore, covers by far the greatest proportion of India's livestock. The third is represented by systems of nomadic and migratory grazing which are characteristic only of certain parts of India, in the mountainous area of the north and the semi-arid regions in the west of the country.

Animal husbandry in the villages is the core of the Indian grazing and fodder problem. Although the individual land holdings of the cultivators are very small and fragmented, they still feel obliged to try to maintain a certain number of livestock almost as part of the family. The working animals and the buffalo are hand-fed to some extent, but the cows, young stock and surplus animals suffer considerably through malnutrition. The pastures or grazing grounds within ready access of a village are almost always reduced to exercise grounds producing little feed of any value during the greater part of the year.

Grassland specialists now know how to regenerate these village pastures by the progressive and gradual closure of small sections to grazing for a number of years. The problem of regenerating village pastures is, therefore, not technical but social and psychological. It is necessary to demonstrate to villagers the benefits of improvement of their pastures from the point of view both fo economic animal husbandry and soil conservation. The present pasture areas are septic foci ; from these areas excess water runs off to cause considerable damage to the cultivated land lower in the same catchment. It is also possible now to state the approximate optimal carrying capacity of village pastures throughout the

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country. This figure will, in the majority of cases, be far lower than the existing livestock population. This is the critical point at which the technician must necessarily stop, and the social worker and the politician begin to consider methods of controlling the numbers of the bovine population.

The recuperation of village pastures and the grazing grounds in waste land and forest land generally is at present based on the capacity of the natural grass associations to revive under protection followed by controlled grazing and for the percentage of palatable species to increase under such treatment. Overseas workers might expect reseeding to be practicable under Indian conditions ; this has not so far proved to be the case, although there is some promise in various methods of establishing superior species in existing stands. After regeneration through natural ecological succession, the associations may be maintained by varying forms of controlled or rotational grazing, but these must in most cases be limited to the grazing season of four or five months and not continued during the remaining months of the year when excessive grazing and trampling cause so much damage to the vigour and composition of the grass stand.

Free-range nomadic and migratory grazing in Western and Northern India raises a number of characteristic problems of its own, which are still difficult to solve. Under this head we consider the annual seasonal movement of stock from the high summer pastures in the Himalayan States to the low elevation winter pastures, and also the regular or periodic movements of stock in semi-desert areas such as occur in Rajasthan and other States of Western India, and which are caused by shortage of water, employment and grazing and fodder resources.

Of the various types of forest land in India (Government, Revenue and private), the Government forests which comprise mainly the reserved forests are beyond the reach of all but 11 per cent of the cattle population of India. Nevertheless, grazing is in fact a perpetual problem in forest management. In certain types of forests, regular grazing is out of the question so long as timber growing represents the primary objective. Other types of forests are of little grazing value, whereas still others benefit from grazing as a method of reducing the fire hazard. Grazing in forests becomes a serious problem because it is confined largely to the fringes of the forests bordering villages and around sources of water in the interior. Overgrazing in these

peripheral regions results in the depletion of the more palatable and nutritive grasses and in general denudation and deterioration of the resource.

It must be admitted that effective management of grazing is difficult, if not impossible, in most of the forest areas under the administration of the Forest Departments and that conditions are far worse in the other forests and waste lands, the management of which is generally vested in the State Revenue Departments.

Forest grazing, like forest burning, is a good servant but a bad master. In association with other biotic factors, grazing is often important in arresting ecological succession in forests and maintaining them at an economically valuable stage. It is, therefore, not correct to say that forestry and grazing are incompatible, but unlimited or uncontrolled grazing has no place in forest management. The exact significance of fire in relation to forest management and grassland succession in India is not yet fully understood. Cutting of grass in forest areas, as distinct from grazing, is a much less harmful practice and does in many districts represent a valuable reserve for critical seasons or years.

The statement known as the "National Forest Policy in India", accepted by the Government of India in 1952, admits, as one of the four vital requirements, the need for ensuring sustained supplies of grazing. The ways in which foresters should approach this problem are indicated, but the line of action proposed is unlikely to be effective or to yield quick results. As far as the regulations in time and place of grazing are concerned, the policy merely suggests that efforts should be made to introduce rotational grazing by explaining and demonstrating its benefits to villagers. Those responsible for framing the policy have been forced to accept the realities of a very difficult situation. Although the foresters know what is desirable in the management of their grasslands, they must await the education of the people before they can carry out the necessary measures. Until such time, politicians and legislators will not support unpopular actions such as the increase or even the maintenance of grazing fees, the annulment of absurd grazing rights and the adoption of regulated grazing. Those responsible for protection and conservation in forest areas exposed to grazing are still losing ground, as is witnessed by the abandonment in 1954 of the age-old and excellent *kancha* system of grazing in Andhra.

Certain aspects of the maintenance of soil fertility are of considerable importance within the context of this publication. Some parts of India are

deficient in minerals ; there is, for example, calcium and phosphorus deficiency in parts of South India, which is reflected in the chemical composition of the herbage and the health and stature of the livestock The economic justification for the application of fertilizers on natural grasslands is a debatable point, although results which are stated to be economically significant have been obtained from experiments on natural grassland in Bombay State. The application of farmyard manure with appropriate chemical fertilizers has, in this case at least, increased the yield of dry matter per acre and the protein, calcium and phosphorus content of the herbage.

The short-duration annual legumes, which may be of a dual- or triple-purpose nature (grain/green manure/fodder), are regarded as the best potential source of high-protein fodder which may be developed in the country, primarily in view of the small size of the average holdings. There is no doubt that an increased acreage of such legumes would, according to the harvesting method adopted, contribute greatly to the fertility of the cultivated land, particularly as regards organic matter content and nitrogen status ; the application of phosphatic fertilizers would increase the benefit to the crops following in the rotation.

The activities of the plant breeder must necessarily be closely related to the overall interpretation of the grazing and fodder situation in India. Throughout this publication, it is argued that there is so far little scope for the development of the so-called temporary ley, although experiments at the Indian Agricultural Research Institute (I. A. R. I.), for example, have shown its merits under Indian conditions ; neither do the ploughing up and reseeding of grassland appear to be practicable on any scale. A farmer with a minute acreage cannot afford to lay aside any of his cultivated land under a temporary grass/legume grazed ley for two, three or four years, and would be better advised to concentrate rather on the short-duration annual legumes. Reseeding of grassland in most cases necessitates ploughing up ; if land is ploughable in India, it must be devoted primarily to the production of food and cash crops plus high-yielding short-term fodder crops, rather than to grass farming.

It is, therefore, recommended that the natural grazing grounds should be managed primarily on an ecological basis, using the information on progression and regression now becoming available in India to maintain an association at the desired level. Attention will continue to be given to indigenous and exotic grasses and

legumes for reseeding open grasslands or fenced pastures, but the chief demand on the plant breeder must, as already stated, be expected to be for short-term fodder plants, and particularly for legumes to be incorporated in existing crop rotations on arable land. These may be of dual- or triple-purpose types, so that the farmer can use his crop in one form or another depending on his seasonal needs or the current economic conditions.

The use of short-term legumes and grasses in special types of alternate husbandry adapted to Indian conditions pre-supposes the greatly increased adoption of mixed farming systems by Indian cultivators. Such systems assume the full integration of crop husbandry and animal husbandry, in which the production of milk, for example, is carried on side by side with the system of cropping in which leguminous fodder crops occupy an important place, and in which full use is also made of the increased quantities of cattle manure which become available. The degree to which mixed farming systems can be adopted in India depends primarily on the size of holdings. So far it is known that mixed farming is practicable on *irrigated* holdings of 5 acres in Anand, Bombay State, or 7.5 to 8 acres in Delhi State. Reference to Tables XCIV and XCV will show the very small percentage of holdings in the principal States of India on which mixed farming may conceivably be adopted.

What should be the future objective of the grassland ecologist and the fodder agronomist in their study of the grazing and fodder resources of India ? The grassland ecologist must learn to appreciate the ecological status and behaviour of the many types of grassland which occur in India. He must be able to go into a village grazing ground, diagnose the stage of succession of the types of grassland to be found there, and indicate those types of ecological and other management which would be necessary before a desirable plant association can be obtained. This desirable association should be of the kind which will give the best type of grazing, both in quality and carrying capacity and which will at the same time ensure optimal conservation of soil and water. The fodder agronomist on his part must develop cultivated fodder crops with or without irrigation to their maximum extent, in order to supplement and reduce the pressure on the natural grazing and to replace as far as possible the low quality cereal straws which are at present the basis of animal feeding.

The joint efforts of specialists will make it possible to state for any particular village the number of cattle which can be maintained on an

adequate plane of nutrition throughout the year. This figure, when it is obtained, will not be very palatable, as it will in most cases be much lower than the existing cattle population.

Many of the facts necessary for demonstration and educational work on grassland management and improvement and on fodder production under Indian conditions are already known, but a great deal of research is still necessary to provide additional information. The existing research programme in India covers activities by the Central and State Governments. The Central Government has, through the Indian Council of Agricultural Research, begun the reconnaissance survey of the grasslands of India already referred to ; this will cover both the major grassland types and also the many sub-types which have appeared under the influence of biotic factors. Four of the specialists concerned in this survey are agriculturists and two foresters. The objective of the survey is to observe and record the botanical composition of the grassland vegetation, to diagnose the ecological status of the many different types, to obtain accurate information on the present and potential yield of dry matter and, therefore, on carrying capacity, and to observe the degree of parallelism between grassland types and forest types. When the survey is complete, it should be possible to define and map the grassland types of India in the same way as Champion has defined the forest types (1935).

In addition, the Indian Council of Agricultural Research is giving financial support to research activities in a number of States, which are primarily concerned with the introduction of short-duration legumes in crop rotations. The breeding of pasture grasses and legumes is, for reasons indicated above, at present confined to the Indian Agricultural Research Institute, Pusa, New Delhi and the Agricultural College, Dharwar, Bombay State.

A stage has, therefore, now been reached in the study and development of the grazing and fodder resources of India in which (a) the whole question has been summarized and reviewed in the present publication and also in a separate publication of the Forest Research Institute on "Forest grazing in India" (*Indian Forest Record*) ; (b) the Grassland Survey has been initiated ; and (c) the study of fodder grasses and legumes is in progress in certain States. This is, however, inadequate in relation to the magnitude of the problem, and a further widening of activities is highly desirable. In planning this work in the larger States in the first instance, it is necessary to recognize

the fact that the Departments of Agriculture, Animal Husbandry, Forestry and Revenue are all directly concerned with certain important aspects of the problem. There does, therefore, seem to be an urgent need for the reconstitution of State Grazing and Fodder Committees, but these should be action committees rather than groups meeting at irregular intervals for mere discussion of the problem. In order that they may operate on this active basis, each of the Departments concerned should have a specialist officer trained and experienced in this particular field. Their activities could be developed somewhat on the following lines, and full interchange of plans, experiences and results should be ensured.

Agriculture Department

The staff of the Agriculture Department should concentrate on the cultivated lands and grazing lands around the villages and not primarily in the agricultural experiment stations and colleges. The village grazing lands are, as repeatedly stated, the core of the grazing problem in India. The officers of the Agriculture Deparment must face up to it and try by demonstration and persuasion to improve these lands on the lines indicated in Chapter IX.

Animal Husbandry Department

The specialists in this Department should study grazing management and fodder production primarily in relation to the various forms of animal husbandry and types of livestock in the different regions of their States. This work can best be done in the first instance on the livestock farms with a three-fold objective, to (a) develop pasture and fodder calendars on the lines of those quoted in Chapter VIII, (b) plan the lay-out of the livestock farms in such a way as to provide the amount of grazing land, hayland and cultivated land (dry or irrigated) necessary to yield the amounts and qualities of animal feeds at the appropriate times of the year necessary to maintain the pasture and fodder calendar, and (c) translate the experience thus obtained ultimately to the village land.

Forestry Department

Forest officers specially assigned to deal with forest grazing problems should, in addition to their routine duties of attempting to manage and conserve the forest grazing resource, conduct trials with the following treatments, adjusted, of course, to their local conditions:

(1) Grazing each year for four to five months, no burning.

(2) Grazing each year for foui to five months, followed by burning in January or February.

(3) Grazing for four to five months in one year, cutting in October/November in the following year.

(4) Cutting in September each year, followed by grazing in November/December.

(5) Year-round grazing plus supplementary feeding when necessary.

(6) Exclosure (full protection from grazing, burning and cutting).

The effects of these different treatments should be observed in relation to the optimal botanical composition of the grassland found to be desirable in the region. Grassland working plans could then be evolved.

The activities of the specialists in these three departments would be co-ordinated by the Grazing and Fodder Committees in the individual States. Co-ordination of State activities could be provided by the formation of a Grazing and Fodder Committee in the I. C. A. R. and the appointment of an adviser in that Council to take over from the F. A. O. specialist responsible for this work since 1951. The work on agrostology and grass and legume breeding at the Indian Agricultural Research Institute should be maintained and developed further as also should the work at the Indian Veterinary Research Institute and the Animal Nutrition Regional Centres on the chemical composition and nutritive value of Indian feeds and fodders. It would further be desirable that the activities of the grassland officers in the State Forest Departments should be co-ordinated by the appointment of a grassland specialist on the staff of the Central Silviculturist in the Forest Research Institute, Dehra Dun, and that grassland work should be discussed fully at silvicultural conferences.

The development of the grazing and fodder resources in India and their places in the general land use, agricultural and forestry systems are not adequately covered in the agricultural education of the country. Universities and agricultual colleges should give special attention to the appointment of qualified teachers in these subjects. This review of the whole subject may be adopted as the text-book for such courses. The recognition of common forest grasses, the principles of ecological succession and the operation of the biotic factor, as well as the problems and techniques of forest grazing management should be taught at the Indian Forest College and the Rangers College, Dehra Dun, using as a text-book the special *Indian Forest Record* referred to above.

CHAPTER II

THE LIVESTOCK PROBLEM

IT may be necessary to remind readers outside India of the consecration of animals to gods and goddesses. The realization in ancient India of the indispensability of the animal kingdom to human beings and of the necessity of looking after animals with the greatest care is the origin of this consecration, the fact that animals are placed on a par with the divine, as enjoined in the *Vedas.* As early as *Rig Vedic* times, there was a school of thinkers who protested against killing such a useful animal as the cow, as is evident by the application to the cow of the name *aghnya*, that which should not be killed (Krishnaswamy 1941). Buddha strongly protested against cow-killing, and this protest gradually increased in volume until the custom of cow-killing was totally abolished in a later age, the killers to be punishable by mutilation or later (Kautilya's *Arthasastra*) by death (a penalty that no longer applies). The bull has also been deified in the Hindu religion. It is the animal ridden by the god *Shiva* ; there is no *Shiva* temple without the emblem of a bull.

Before proceeding to review recent surveys of the livestock-feeding problem in India, it is in eresting to refer to the position nearly four centuries ago, during reign of the Emperor Akbar. The *Ain-e-Akbari*, written by his Prime Minister Abul Fazal, describes the economic position during that period. The regulations for the maintenance of dairy cattle, possibly attributable to Akbar's Finance Minister, Todar Mal, would provide a good basis for a dairy industry in any country today. They include careful selection of dairy stock, scientific standards of feeding to promote milk production, feeding of concentrates in proportion to milk yield, maintenance of individual records of milk production, tests of quality, fat content, etc. and fortnightly inspection of stock to ensure that the correct ration has been fed.

Now, in modern India, animal management is very poor, semi-starvation is the rule ; milk production per animal is steadily decreasing. The three main directions of livestock improvement are breeding, health and nutrition, and in India most certainly today, the greatest problem and the most urgent one to be solved is the nutrition of domestic livestock.

Agricultural scientists working in India, or visiting the country on special missions during the past 60 years have dealt in varying detail with the problem of improving the grazing and fodder resources by managing and utilizing India's grasslands correctly and increasing the production of fodder from cultivated land. It has been fully realised that correct management of natural grassland, if it could be achieved, would be a great contribution to soil conservation ; that the cultivation of fodder crops and more particularly legumes in arable rotations and mixed farming systems would improve the fertility and reduce the erodibility of the soil, that the provision of adequate amounts of and a correct balance between proteins and carbohydrates would be the basis of an improved livestock industry, to provide more milk for better nutrition to a primarily vegetarian people, and better draught power for the cultivation of the land.

More particularly in the surveys dealing with the improvement of livestock and especially of dairy production, correct animal feeding is repeatedly stressed as being essential before any improvement by breeding or better disease control can become effective. One writer quoted below states that a 300 per cent increase in milk production in India could be obtained from less than the present number of cattle if they were adequately fed and managed for two or three bovine generations. But all the surveys of the livestock position ultimately come face to face with certain social, economic and religious difficulties which will have to be solved by the people themselves before it will be possible to feed improved Indian dairy cows or buffaloes correctly.

The now classic "Report on the Improvement of Indian Agriculture" by Dr. J. A. Voelcker (1893), then Consulting Chemist to the Royal Agricultural Society of England, deals with the problems of grass and fodder crops in the years before their management and improvement had become an exact science in Great Britain or elsewhere. Voelcker described the various types of grazing areas available to Indian cultivators and noted the existence of large grassland areas within the forests ; he considered that the provision of grazing in forests was "a desirable and legitimate objective", which could benefit the agricultural community particularly in times of drought. In normal times, forest grazing should be carried on only under such restrictions as would cause it not to interfere with the other purposes which a forest or reserve should serve. Voelcker then discussed the utilization of village grazing grounds, the so-called 'village waste', and the provision of grazing along canal banks and in plantations ; the desirability of special 'fodder and fuel reserves' was especially stressed. Grass growing and the supply of pasturage

might become a part of the farming system on the cultivator's own holding. An extension of the system of grass-farms and utilization of uncultivated grasslands were recommended ; methods of making hay and silage at Government Grass and Experimental Farms were examined and compared with costs of production in England. A change was advocated in the Commissariat Department, whereby the services of experienced men might be retained in the management of grass farms, and a special Forage Branch of the Commissariat formed.

Voelcker noted that cattle were in better condition where fodder crops were grown ; he recommended the extension of fodder crop cultivation, preferably in fields hedged by prickly pear. As little was known of the relative values of Indian grasses and fodder plants, the employment of an agricultural chemist was recommended.

Dr. R. S. Hole, a former Forest Botanist at the Forest Research Institute, appears to have been the first to have thought of a comprehensive survey of forest grasslands in India. In a *Note on the chief fodder grasses of Indian forests* (1913), he wrote : "A systematic study of forest grassland is now being undertaken by the Forest Botanist at Dehra Dun with the main object of determining (1) which forest species really are of greatest value and (2) what are the conditions on which their healthy development and natural distribution chiefly depend. A beginning has recently been made with this work in Uttar Pradesh where local Forest Officers are now preparing maps of their principal grasslands. It is greatly to be desired that similar work should be carried out in other provinces". This laudable scheme appears to have come to nothing. No survey of the grasslands of India was carried out then or at any time subsequently. Dr. Hole and Dr. Bor, former Forest Botanists, have valuable publications on grasses to their credit, but these are of local or provincial interest, and do not attempt to survey the distribution of grasses or grasslands.

The Royal Commission on Agriculture in India presided over by Lord Linlithgow (1928), was the first to examine and report specifically on the conditions of agriculture and rural economy in India. The Famine Commissions of 1880, 1898 and 1901 the Irrigation Commission of 1903, and the Committee on Co-operation of 1915 made many recommendations for improvement of agriculture and promotion of welfare and prosperity of the rural population.

An important historical point in the Report of the Royal Commission has a bearing on the possibility of co-ordinating grassland and fodder research

throughout India at the present time. As a result of the constitutional changes of 1919, the Government of India divested themselves of powers of direction and control of certain subjects, including agriculture and veterinary science. The administration of central agencies and institutions for research and for professional and technical training was retained as a "Central" subject, but no specific provision was made for co-ordinating the work of these with that of similar institutions in the provinces. In the matter of research, the provincial departments were left without the stimulus of a central organization which could guide and co-ordinate their policy. It was to meet this need that the Imperial (now Indian) Council of Agricultural Research was formed.

The Royal Commission found that feeding and breeding were, in that order, the two important factors in cattle improvement. The crux of the problem is the period of scarcity which in most parts of the country is the two or three months preceding the break of the south-west monsoon in June/July. Since it was the curtailment of uncultivated land as population increased which was the chief cause of the overstocking of village grazing grounds, many witnesses advocated the extension of grazing land. The Commission did not find that large additions to existing grazing areas were possible and recommended the increasing of productivity of land already growing grass. The scope for such efforts was considered to be great, by the following means :

(*a*) Grazing on the common land should be regulated and rotational grazing established with the consent of the majority of those possessing grazing rights, and by means of authority conferred on a group of villagers, *e.g.* a *panchayat* or co-operative society.

(*b*) A definite area may in some cases be separated for a village co-operative cattle improvement society.

(*c*) In hilly districts, where the grazing facilities were assumed to be better than elsewhere, an attempt might be made to demarcate areas to be assigned at nominal rates to groups of occupiers of village lands on the following conditions :

The area shall be grazed in rotation, cattle not owned by the group shall be excluded, and part of the area shall be reserved for cutting grass for use in the hot season.

The Commission saw the cutting and storage of dry grass as an important supplement to or substitute for natural grazing. Ensilage was also regarded as

a desirable development, but this technique was too difficult for general adoption by cultivators. Other suggestions were concerned with the use of a chaff-cutter, the addition of cheap meal and condiments to make straw more palatable, harvesting at the correct time to obtain full value from the straw, and the encouragement of the growth of fodder crops. Berseem was thought to have great possibilities if cheap seed could be made available. The cultivation of leguminous crops should be encouraged by remission of charges for water from government sources of irrigation or by grant of concession rates.

The Royal Commission also considered forests in their relation to the agricultural economy, particularly as regards grazing and the provision of fuel and timber for the domestic needs of the cultivator. It was agreed that their role in the protection of soils liable to erosion also has an agricultural bearing. At that time, grazing in forests was permitted under the Forest Code on payment of certain fees or free of all charges. The Commission considered that grazing might with advantage be replaced by grass cutting, although they recognized that grazing would long remain an important feature of forest economy. It would, therefore, be desirable to determine as soon as possible the intensity of grazing consistent with the proper development of forests and the preservation of desirable grasses.

It was expected that the importance of cut fodder would increase with the expected extension of stall-feeding ; the forest and agricultural officers should, therefore, devise schemes for the improvement of grasses in forests and the encouragement of grass cutting in preference to grazing. Railway administrations should offer the lowest economic rates for the transport of fodder. Forest areas should be reclassified into areas most suitable for the growth of timber or for fuel plantations, or areas which should be preserved on climatic or physical grounds, those most suitable for development as fodder reserves or grazing grounds, and areas which should be handed over for ordinary cultivation. The Royal Commission recommended that Forest Departments should have a special division in charge of minor forests, fuel plantations, village woodlands and waste land, chiefly used for grazing and often included under unclassed forests.

In the winter of 1936-37, Sir John Russell visited India primarily to report on the way in which the Imperial (now Indian) Council of Agricultural Research had discharged its primary duties of co-ordinating and promoting

research in plant industry in particular (1937). Russell concluded incidentally that many of the livestock in India were inadequately fed, and that this deficiency in food nullified other attemps at livestock improvement by distribution of better bulls; for example ; "If it were feasible, the best course would be a large reduction in the number of animals so as to bring the livestock population more into line with the supplies of food, but this cannot be done rapidly." Economic pressure on land and castration of scrub bulls were seen as possible influences in this direction. The claim that more animals were needed because of the demand for their dung for fuel was stated to be unfounded, as "a given quantity of food produces more manure if fed to one animal than to two".

Russell noted that, over much of India, the only fodder for animals consisted of the stalks or straw of the grain crops, rice, wheat, *juar*, millets, with such grazing as was available. Only a few provinces grew fodder crops ; the fodder crops as a percentage of the total area sown in the Punjab, Bombay, Uttar Pradesh and Madhya Pradesh at that time were 16·1, 7·6, 3·2 and 1·7 respectively.

The grazing was stated as falling into two main groups, associated respectively with forest and cultivable waste, the latter being much more important. In the five Provinces possessing much forest, only 10 percent of the cattle had at that time access to forest grazing. As they could reach only the easily accessible areas, these became overgrazed, while the less accessible were not utilized. With control of grazing, the pasturage remained good; but without control serious damage occurred ; the Punjab foothills were quoted as an example (see also Gorrie, 1938). Russell stated that improvement of grazing areas required two regulations :

(1) Restriction of the period during which grazing is permitted, all animals to be excluded during the monsoon ;

(2) Rigid restriction (by regulation or by increasing grazing fees) of the numbers of animals finally admitted, to a rate of about 2 acres per head.

Support was given to Sir C. G. Trevor's Committee's recommendation that each Province should have a standing Fodder and Grazing Committee composed of officers deputed by the Forest and Revenue Departments and an Animal Husbandry Officer, to study the waste lands and advise on their

development. Russell recommended the addition of an Agricultural Officer to the group.

Russell also stressed the need for closure, rotational grazing, control of time of grazing, trials on manuring of heavily grazed enclosed land, and provision of mineral licks. It was considered that enclosed land might be improved by reseeding with mixtures of grasses and legumes, and further trials were suggested, supported by a study of the indigenous and exotic species available.

The introduction of fodder crops into rotations would mean more food for animals, and so more manure and enhanced fertility for the soil. Russell drew a parallel with the introduction of clover and other soil-improving crops into the farming systems of Britain and the countries of Western Europe ; the additional yields of grain more than compensated for the area taken from grain and put under fodder crops, particularly legumes. Only in the Punjab were valuable crops such as berseem (*Trifolium alexandrinum*), senji (*Melilotus parviflora*) and shaftal (*Trifolium resupinatum*) used to any extent ; there was a need to produce improved strains and to ensure an adequate supply of clean seed. Various exotic grasses such as Napier and Guinea yield well with irrigation and manuring. Where natural grass is sparse and fodder crops are grown, cattle are in much better condition than in the wetter parts of India, where the coarse, rank natural grasses are of poor quality and of little value for dairy or working animals. A thriving dairy industry would demand the cultivation of leguminous and other fodder crops.

Dr. Norman Wright (1937) dealt with the livestock aspects of Indian agriculture, parallel with Sir John Russell's crop survey. Again we find the observation that a superficial examination of Indian country cattle shows that they are malnourished and frequently emaciated in appearance. The other symptoms of malnutrition are their low milk yield, slow rate of growth, late maturity and long dry periods ; it is quite usual for a cow to drop her first calf at four to five years of age and to have calving intervals of up to 600 days. Yet milk yields can be increased by at least 60 per cent solely by better feeding and management, and the other failings can similarly be removed to a large extent.

Although Wright admits that it is difficult to arrive at any accurate estimate of total quantities of feeding stuffs on an all-India basis due to the inaccuracy and inadequacy of available statistical data, he does attempt to arrive

at a figure (Table 1)

TABLE I

Total available feeding stuffs (according to Wright, 1937)

	Available quantity (1000 tons)	Calculated nutrients (1000 tons)				Nutritive Ratio
		Digestible crude protein	Digestible carbohy-drates	Digestible fats	Total digestible nutrients	
Dry fodders ..	111,000	1,010	34,580	383	36,480	1:36.0
Green fodders ...	100,000	1,000	10,000	250	11,562	1:10.6
Concentrates ..	1,500	450	375	150	1,163	1: 1.6
Cotton Seed ...	2,300	300	690	367	1,818	1: 5.1
Total ...	214,800	2,760	45,645	1,150	51,013	1:17.5

and to use this in determining how far it meets requirements for milk production alone. Calculating on this basis he found that there is an apparent surplus of total digestible nutrients and the quantities of digestible crude protein almost balance. But this does not cover the young stock which require large quantities of protein as well as energy for growth, nor the very considerable requirements of working bullocks.

Wright did not believe that the grant of additional grazing land would alleviate the shortage of fodder, for the immediate tendency would be to overgraze these areas and leave them barren of herbage within a comparatively short period. There still remains the period of eight or nine months when drought prevents the growth of natural herbage, "In any event, grazing under Indian conditions cannot be looked upon as a satisfactory source of food for milking cattle".

Basing his discussion on requirements of total digestible nutrients and of protein, Wright then considered how the necessary great increase in fodder supplies could be obtained. The problems were stated to be :

to increase the supplies of fodder of type and quality suitable for milk production and

to ensure that the available supplies are utilized economically.

It was stated categorically that, for the necessary increase in the supply of food for milking cattle, it is useless to rely on coarse dry fodder. Such

fodder contains too little protein in comparison with total nutrients to be suitable for milk production. For milk production, the nutritive ratio of the ration must not be wider than 1: 10, and the higher the yield of milk the narrower should this ratio be. The nutritive ratio furnishes, in fact, an excellent index by which the suitability of various fodders, can be judged. Dry fodders, such as rice straw and wheat straw, have nutritive ratios of over 1 : 40 and are, therefore, obviously unsuitable for milk production. Grasses, such as Sudan grass, Guinea grass, elephant grass and the spear grasses have nutritive ratios of between 1 : 12 and 1 : 10. These grasses are, therefore, reasonably good sources of nutrients for milch cattle. But the fodders of outstanding value are the leguminous crops such as berseem and lucerne. These fodders have nutritive ratios of 1 : 4 to 1 : 6 and are ideal for milk production provided due regard is given to the protein/carbohydrate ratio.

Wright attempted to show how yields and costs of production of berseem and lucerne compared with the more common but less nutritious crops such as *juar* or maize. He found, however, that figures varied not only between one locality and another, but between farms in the same locality, including reliable sources such as Military Dairy Farms. It was possible to conclude nevertheless that berseem and lucerne yielded just as much as green *juar* and maize and that lucerne could be grown as cheaply as green maize, berseem as cheaply as green *juar*. Wright's views on the incorporation of these and other fodder crops in a 'mixed farming system' are discussed elsewhere (Chapter XV).

Although the economics of production do not at the moment enter into a villager's calculations, it would be an advantage to be able to show that the provision of adequate amounts of good quality green fodder is an economic proposition. Wright calculated the feed cost per lb. of milk (1936-7) as seven pies, and quoted figures for Military Dairy Farms as between four and six pies. There is a 'need for including in any future investigations not only the costs of cultivation of the fodder crops, but the effect of feeding these crops on the cost of production of milk as well as their influence on soil fertility.'

Wright concluded his discussion of fodder resources by referring to ensilage, hay-making on tripods or fences, and the cutting of coarse and other fodders at the best stage of growth for production of quality feed. Attention was drawn to the great need to increase the available protein concentrates such as linseed, cottonseed and groundnut cakes. These concentrates have nutritive ratios of from 1 : 1 to 1 : 3 and form by far the most valuable sources of nutrients

for milk production. The total quantity of concentrates available at that time for cattle feeding in India was estimated to be about 3,800,000 tons (see Chapter VII). In addition, about 325,000 tons of oilcakes and over a million tons of oilseeds were exported annually. If the extracted cake from those two sources could be retained in India, it would result in a considerable increase in the available quantity of protein-rich concentrates.

The Royal Commission stated that the only possibility of conserving this valuable potential supply of cattle food was by developing the Indian oil-crushing industry. In this connection it would be sound policy to give active encouragement to the export of vegetable oils, since this would indirectly increase the supply of oilcake in the country. Improvement in the efficiency of the mills would also tend to lower the price of oilcakes, and so make these products more readily available for the feeding of milch cattle.

The Famine Inquiry Commission (Chairman : Sir John Woodhead ; Members : S. V. Ramamurty, Sir Manilal B. Nanavati, M. Afzal Hussain and W. R. Aykroyd) dealt with animal husbandry in Chapter VII of their Report (1945). "Feeding is of crucial importance, for no lasting improvement can be brought about by breeding alone, since improved breeds deteriorate rapidly if not fed adequately. The vast majority of Indian cattle are grossly underfed." The Commission then quotes the figures of fodder supply in relation to demand calculated by Burns (1944), and gives his outline of agricultural regions based on rainfall, namely under 30 inches, from 30 to 70 inches, and over 70 inches.

If an increase in the area under cereals is accompanied by an increase in the number of bullocks, there may be little or no increase in quantity of straw per animal, hence the need for using the tractor in new developments. An increase in yield of cereals per acre would increase the absolute amount of straw available for cattle feeding.

'Grazing areas fall roughly into two groups ; cultivable waste and forest lands.........only a small proportion of the total cattle have access to forest grazing lands. The area of grasslands is decreasing owing to the increasing pressure of the agricultural population on land, and this process is likely to be accelerated in the future in view of the need for increasing the area under food grains. It is, therefore, essential that the best possible use should be made of all available grasslands.........We recommend that experiments in reseeding with indigenous

and foreign drought-resistant varieties, rotational grazing and manuring should be undertaken as soon as possible. All these experiments will require that the land should be enclosed'.

In discussing the use of other uncultivated land excluding current fallows, the Commission refers to Sir Herbert Howard's monograph on 'Post-war forest policy for India' (1944), in which he recommends that large tracts could be used to provide timber, fuel and grazing by the establishment of minor forests.

"In the absence of good grazing, green fodder is essential for the maintenance of the health of the animals.........We doubt, however, whether it is possible in many parts of India to bring the production of green fodder crops up-to the required level, unless it proves practicable to adopt mixed farming on an extensive scale". The quantity and quality of oilcake can be improved by carrying out as much as possible of the crushing of oilseeds in India, and by extending the area under pulses. Although the great need is for pulses for human consumption, any increase in area will increase the amount of bulk available to be fed as concentrates.

R. A. Pepperall of the British Milk Marketing Board toured India as Milk Marketing Adviser to the Government of India and reported on "The dairy industry of India" (1946). With regard to feeding, the Report states that this should consist of roughage such as hay, a sufficiency of green fodder and suitable concentrates. The state of semi-starvation of Indian dairy cattle is the main reason for the very low milk yields ; the quickest way to increase them can be found in adequate feeding whereby an immediate reward of 100 per cent or more in milk yield can be assured. Recommendations include the following : (a) the cow should be developed for dual-purpose use, milk and draught, (b) cattle should be moved from city stables to colonies in more natural environments, (c) berseem should be grown more extensively under irrigation, (d) village areas should be utilized for the cultivation of green fodder rather than for grazing, (e) the export of oilseeds and cake should be banned, and (f) the export of cattle from the Punjab to Bombay and Calcutta should be replaced by the export of evaporated milk manufactured in the Punjab.

Professor H. D. Kay (1946) discusses the place of feeding in reaching the target of an increase of at least 300 per cent, if India's requirements of milk and milk products are to be met even approximately. "The difficulties in improving

Indian milk production and consumption and developing the Indian dairy industry on the right lines are of a different order of magnitude than any at present facing Western countries. Today's essential and fundamental obstacle is the shortage of feeding stuffs for milk production, the shortage of concentrated protein food being particularly severe." Milk yields are absurdly low when compared with the proved potentialities of many Indian breeds as milking animals.

Apart from the problem of improving fodder production and agriculture generally, there are the "social, economic and religious difficulties, some of them of an intensity which can only be appreciated by observation at first hand, which have to be overcome before Indian agriculture can hope to meet the nutritional needs of the Indian dairy cow or buffalo or Indian dairying can hope to meet the nutritional needs of the Indian people".

Kay gave as a conservative estimate the fact that India was at that time (and, therefore, still is) carrying and attempting to feed nearly 90 million cattle too many (230 million instead of 144 million). The 300 per cent increase in total milk output required by the nutritionists could be provided by less than the total cattle population today, and that without improving their potential milking capacity, if they were adequately fed and managed for two or three bovine generations.

Kay concluded, "it is clear that, if food and feeding-stuff supplies in India are to be even approximately equal to the requirements of the present human and animal population (quite apart from meeting the needs of any increased population) either (i) much more food and feeding stuffs must be produced at home, or (ii) much more food and feeding stuffs must be imported from overseas, or (iii) either the human or the animal population or both must be diminished, or (iv) there must be some combination of (i), (ii) and (iii)".

Perhaps the most important obstacle in the way of increased fodder production, the small size of the farming units, is discussed by Kay as follows: "There is another consequence of the increase in human population in India which severely handicaps the dairy industry. As a result of inheritance laws by which a father's estate is divided amongst his sons, the individual cultivator's holdings have diminished in size to such an extent that, for the whole of India, 60 per cent of the peasant holdings are now less than five acres each ; in some provinces the average acreage is not much above two.

Further, these small holdings may not even be in one piece, but scattered perhaps over a square mile or more. With such small and scattered units and animals so seriously underfed, milk is produced inefficiently and, therefore, expensively, by the seer per farming unit per day rather than (as in even the smaller milk-producing units of most Western countries or of New Zealand or Australia) by the maund or two maunds per day. Not only its production, but also its collection and transport to consuming centres is, therefore, difficult and costly, particularly under Indian conditions of very poor secondary roads, practically no cooling facilities, and high temperatures.

The peasant's main, immediate dairy problem is that of providing sufficient feeding stuffs containing enough protein for even his very small stock of milk-producing animals. Agriculturally this problem is intensified not only by his very tiny acreage, but often by lack of water over a large part of the year, by shortage of fertiliser, by his use of cow and buffalo dung as fuel, by his limited knowledge of anything but traditional agricultural and dairy husbandry technique. Moreover, before his 'dairy' animals are fed, he must first provide food for his draught animals, without which he cannot cultivate his land at all. To maintain two draught bullocks on five acres or less, which many peasants attempt, makes an entirely disproportionate demand on his small food-growing area. There are far too many who prefer carrying out mere subsistence farming. The size of the milk producing unit must be increased until a minimum herd of not less than six milking animals is maintained as a unit. On a short-term basis, this may perhaps be done by co-operation between three or four small cultivators".

Finally, there is reference to the diversion of high quality feeding stuffs to feed "useless and superannuated bovines" in many but not all of the *gowshalas* or *pinjrapoles*, or to use a more modern term, concentration camps; and the damage caused by roving ownerless cattle, monkeys and other vermin.

In 1947, Dr. A. B. Stewart submitted a report to the Imperial (now Indian) Council of Agricultural Research on soil fertility investigations in India, with special reference to manuring. Stewart naturally dealt with some aspects to be discussed later in this book, namely, the use of bulky organic manures including stable manure and green manure legumes, and the importance of properly designed rotations incorporating legumes. The main pre requisite for the success of green manuring is the availability of sufficient moisture to ensure

the decomposition of the green crop after it has been turned under ; if a minimum of five to six acre inches of water is available, green manuring has usually given beneficial results. Mukerji and Agarwal (1940) have reviewed the whole problem of green manuring in India, the range, choice and relative merits of various leguminous and non-leguminous green manure crops under different conditions of soils and crop rotations, the use of leaves, tender twigs and stems of many trees and wild plants for paddy, cultural practices for green manure crops, dual purpose crops to produce fodder or fibre as well as green manure, improvements in soil fertility, effect of green manures on physical, chemical and other properties of soils of varying texture, and the economics of green manuring.

Stewart regarded green manuring, the phosphatic manuring of legumes, and the general aspects of stock feeding and the production of stable manure as together representing 'one of the major problems confronting Indian agriculture today'. Soil fertility can undoubtedly be improved by such methods, and here the main problem is not one of the efficacy or scientific soundness of the methods as such, but their economic practicability in the fields of cultivators who do not have the means to meet the initial outlays involved. The chief hope is in raising the output of land under cereals or cash crops by the use of mineral and other quick acting fertilizers, so freeing a proportion of the land for fodder crops. Thus, one may provide fodder for the stock which are to provide the manure which can be used in association with the necessary fertilizers to produce the crops on which the economy of the holding depends.

Stewart recommended that careful study should be made of the manurial and other practices adopted by good cultivators in the various districts. These would cover methods of cultivation or tillage, rates, times and methods of seeding, and systems of crop rotation. World experience has shown that growing crops in rotations is one of the fundamental principles of good farming. More experiments and demonstrations are required in India, in relation to different soil types, and under dryland or irrigated conditions outside government farms. The need to investigate the introduction of a legume into the cotton/*juar* rotation in large areas of peninsular India is stressed. 'The widely accepted policy of sectionalizing agricultural research into a series of single crop compartments' is not considered wise ; Institutes specializing in one crop such as rice, cotton or sugarcane tend to concentrate on the breeding and agronomy of that crop alone, instead of investigating its general place in farming systems in rotation with the

other crops of typical soil and farming areas, with special emphasis on the high protein, soil improving legume.

This introductory review of earlier surveys of Indian crops and livestock farming indicates a general realization of the great importance of grassland management and fodder production in Indian agriculture. Grassland protects the soil and assists in correct forest management as well as providing roughage and grazing for livestock ; cultivated fodder crops and particularly legumes contribute to soil fertility and provide nutritive fodder for high-grade dairy and working animals. Together, grassland management and fodder production represent the keys to correct land use and agricultural improvement in India, and yet they are the most neglected aspects in research and practice.

A number of other surveys and studies of national fodder resources have appeared which are discussed in later chapters of this book. Here, in passing, we may refer to the publication by Burns (1944) entitled "Technological possibilities of agricultural development in India". The figures for production of livestock and of concentrates and roughages refer to British India before independence and partition, and are, therefore, replaced by more up-to-date figures for the Indian Union given in Tables III and VI. Burns concluded that there was a great deficiency of both concentrates and roughages. The available supply of these feeds was considered to be sufficient for only 29 and 78 per cent of the existing cattle population ; no allowance was made for the great acreage of forest grasslands which are, however, available to only a small percentage of animals (see Table LXVIII).

CHAPTER III

DEMAND, SUPPLY AND COMPETITION FOR RESOURCES

THE BALANCE SHEET

IN assessing the grassland and fodder resources of a country, it is necessary to consider a type of balance sheet with resources on the supply side, and the livestock requirements on the demand side. In subsequent chapters, we shall attempt to give some idea of the supply position, although this is extraordinarily difficult to present in concise and even reasonably accurate terms ; the natural grasslands of India on which so many of the livestock depend are difficult to assess either in total acreage or in yield.

The grassland and fodder resources are among the most complex agricultural resources to assess in any country. It is more difficult to assess the actual and potential livestock carrying capacity or the yield in terms of hay of a natural grassland area which is constantly liable to vary in botanical composition in relation to season and previous management than it is to assess on an acreage or country basis the actual and potential output of more measurable products such as cereal or legume grains, fibre, sugar and oil crops.

LIVESTOCK POPULATION AND PRODUCTION

The first item to consider on the demand side of the balance sheet is the number of livestock and poultry in India in 1951 (Table II). It is known that the livestock population of British India increased by 46 per cent between 1912 and 1935. Table II shows a comparison for the Indian Union between 1945 and 1951, but these years must not be regarded as directly comparable as there was an increase in the reporting areas in the latter year.

Indian livestock are kept to yield the products listed in Table III and to provide draught for cultivation and transport and dung for fuel. Apart from a limited number of Government and co-operative town-supply dairies and the big farmers, the great bulk of India's livestock belongs to individual small farmers in the villages. The way in which the stock on larger properties are fed and the nature of their demand for grazing and fodder are given in Chapter VIII.

The small farmer keeps oxen for work, a buffalo to produce the milk from which he prepares his *ghee*, and a cow to produce and suckle male calves for use ultimately as draught power for cultivation. The dung produced by cattle is an important commodity in Indian village life. Much of it is collected by village women, made into dung cakes and dried for subsequent use as fuel. Accurate estimates of amounts are not possible, but figures generally quoted are that 40 per cent of the dung is used for fuel, 40 per cent is used as manure and 20 per cent is wasted. These facts are important in relation to the possible use of fodder crops and concentrates via the animal as a source of soil fertility. No immediate alternative to the use of dung as fuel can yet be visualized.

The great and over-riding problem in the Indian livestock economy is the presence of large numbers of aged animals, of bullocks too puny for work, and of cows which produce very little milk for their young. The absence of cow slaughter and the inadequate feeding of the young stock which arise from the promiscuous uncontrolled breeding of these useless animals merely tend to swell the numbers. There is, therefore, ever-increasing competition for the small feed supply available.

Due to the control of epidemics, the mortality rate in livestock has been reduced, and the population is being maintained at a high level. Steps are being taken by controlled breeding in key villages and similar projects to improve the strains of livestock. Both these measures widen the gap between the livestock and the fodder and grazing resources of the country. The increased numbers demand more in quantity and the improved livestock more in quality, both extremely difficult objectives to attain.

Methods of Estimation

The existing livestock census (Table II) is based on the method of total enumeration, but this is recognized as not being very accurate. In order to have a check over these figures and to obtain correct information concerning the numbers of the different types of livestock, the Indian Council of Agricultural Research has initiated a scheme for the improvement in the first place of statistics concerning the bovine population, based on the random sample method. No such study is being made into the method of estimating livestock products. The figure for milk quoted in Table III (Government of India, 1950) is obtained from (1) average milk yield per day, (2) lactational yield, and (3) annual yield per animal in milk in accordance with the information and data available locally. In arriving at these figures, the percentage of

animals which calve annually, interval between calvings, length of lactation and yield per lactation were all taken into account. In some of the areas, e. g. Rajasthan, where greater attention is paid to the rearing of male calves, some cows are partially milked and some not milked at all.

The figures in Table III represent a estimate of the quantities actually drawn into the pail and exclude any amount taken by the calf directly from the udder. The same publication gives a figure of four million tons as the amount of milk consumed by suckling calves ; Dr K. C. Sen considers that this figure should now be increased by at least 10 per cent to allow for the increase in cattle population

THE DEMAND FOR MILK

While on this subject, the fodder agronomist might be justified in asking what type of livestock production he should attempt to cater for in the far-flung future when the livestock numbers and, therefore, their quality can be brought under control. A recent I. C. A. R. questionnaire issued to agriculturists and nutritionists posed the problem : "Do you agree that mere increase in the cereal output will not give us a balanced diet and that increase in 'quality food' such as milk and milk products is essential for better nutrition of our people ?" Most of the specialists who replied stated that current efforts should be concentrated on quantity and, therefore, on increased production of cereals and pulses. One dairy specialist asked whether there is not a tendency to place too much emphasis on the so-called 'quality foods'. The first thing is to fill the belly, rather than to attempt to provide scarce and expensive items for the diet. "The consumption of more than the present 2 to 3 oz. of milk per day will be difficult to achieve as India is not a nation of milk drinkers. One may even doubt the dietetic value of milk and milk products for the people of Eastern nations ; the Chinese and Japanese remain physically and mentally vigorous without any milk in their diet. The findings of Western Scientists on the nutritive value of milk and milk products require to be thoroughly checked in a large-scale investigation".

On the other hand, India is primarily a vegetarian country. As such, most of the people would depend upon milk or milk products as their only source of animal protein. If animal protein is essential, the low consumption per capita quoted above would be reflected in the health of the nation. From this point of view, therefore, one has to consider seriously whether a rapid increase in

milk production for rural and urban areas is not desirable, particularly with regard to the more vulnerable group of the population (growing children, nursing mothers).

Livestock Numbers In Relation To Cultivated Acreage

Sen (1952) has calculated that an increase in the fodder crop acreage of about 10 per cent is necessary to provide an improved fodder basis, particularly of green fodder, for Indian livestock. Table IV gives, among other figures, the present number of adult bovines per acre of fodder crops in the States of the Indian Union. Allowing for the possible inaccuracy of the livestock figures, the figures for the Punjab (3·4 per acre of fodder crops) are almost within reason, while at the other extreme we have West Bengal with the fantastic figure of 1572 bovines per acre of fodder crops. All these figures must be taken with a certain amount of caution ; for example, in West Bengal, the fodder crop acreage for the previous year is given as 22,000, which would reduce the bovines per fodder acre to about 500, still four times that quoted by Sen (1953), namely, 126 for Bengal pre-partition. Of the 12 million acres in this State, 9 million are under monoculture rice in which it is most difficult to interpolate a leguminous grain or fodder crop in the rotation. The West Bengal figure is interesting in relation to the figure quoted in Table LXVIII (page 284) for the percentage of forest-going cattle in this State, namely 0·05 per cent of the total cattle population.

Objectives In Forest Reservation

These are stated under the heading 'Proportion of forest areas' in the ational Forest Policy (Govt. of India, 1952) as follows :

> "The proportion of land to be kept permanently under forests would naturally vary in different regions. Practical consideration suggests, however, that India, as a whole, should aim at maintaining one-third of its total land area under forests. As an insurance against denudation a much larger percentage of the land, about 60 per cent should be kept under forests for their protective functions in the Himalayas, the Deccan, and other mountainous tracts liable to erosion. In the plains, where the ground is flat and erosion is normally not a serious factor, the proportion to be attained should be placed at 20 per cent ; and in view of the pressure of agriculture,

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efforts at the extension of treelands should be concentrated on river banks and other convenient places not suitable for agriculture. At the same time it must be realised that even distribution of forests in all physical regions is as important as its over-all proportion. In certain localities deficient in forests, therefore, afforestation of marginal lands and eroded river and village waste-lands should be undertaken. Forest area in excess of the indicated proportion, if any, should, however, not be sacrificed. To maintain an over-all average, it is essential that States better suited for the growth of trees should help to make good the deficiency in those parts where climatic and edaphic factors militate against tree-growth."

Competition Between Human And Animal Nutrition

Recently, a Joint Committee of the Nutrition Advisory Committee of the Indian Council of Medical Research and the Animal Nutrition Committee of the Indian Council of Agricultural Research considered the inter-relationship of the demands for nutriment for human beings and livestock. A draft memorandum (Govt. of India, 1952) circulated for consideration and comment by interested persons in both fields of activity was approved with slight amendments at a further session of the Joint Committee held at Gwalior on November 24, 1953, under its Chairman, Dr K. C. Sen.

The Joint Committee accepts the fact that cattle are the backbone of Indian agriculture ; animal labour is perhaps the main contributor to soil fertility. It is, therefore, natural that, if Indian agriculture is to maintain the nation in health, the efficiency of the cattle population must be high. As has been said repeatedly in the foregoing chapter, the factor which requires primary attention in this respect is their adequate and balanced feeding.

The Committee agrees that the 'Grow More Food Campaign' is a move in the right direction as far as human nutrition is concerned, but it is concerned chiefly with cereal production. One does not generally realise that the state of human nutrition depends not only upon agricultural produce, but also on the supply of those foods which directly originate from animals. Besides, one cannot overlook the fact that almost all agricultural production from the Indian land depends on animal labour. Hence the problem of maintaining the efficiency of animals by proper nutrition is of paramount importance, for ultimately the care taken of the animals will be reflected in the increased supply of different types of necessary foodstuffs required

by man. Unfortunately, there has been a tendency recently to consider the needs of the human population only, leaving the animals to fend for themselves on such materials as are available as by-products of produce cultivated mainly for human consumption or on overgrazed grassland and readily accessible forest areas. The Committee, therefore, emphasizes that the final solution of the food problem in India will depend on the success achieved in the integration of the needs of the human and animal population in relation to the capacity of the land for agricultural production.

A proper understanding of the problem of human nutrition *vis-a-vis* animal nutrition and a successful attempt to integrate the efforts towards improving the nutrition of both would be possible if the individual requirements of these two groups were reviewed carefully. It is necessary to discuss this question from several aspects, some of which are of a long-term nature ; one of immediate importance is the allocation of the present resources of food supply between the human beings and animals with a view to their full and judicious use.

At present there appears to be competition between human beings and animals not only for arable land, but also for certain types of foodstuffs ; men, being in a position to appropriate all the supplies, have gradually deprived the animals of their share, so much so that an attempt at encroachment is being made upon some foodstuffs which were until now considered to be natural food for animals. For instance, if the existing total output of work and milk is to be sustained on the basis of the current system of stock feeding, the requirement of some of the feeding stuffs such as maize, barley, gram, bran, oilcakes and cotton-seed are 4·9, 4·9, 2·8, 2·2, 5·8 and 1·4 million tons respectively. In view of the overwhelming human demand, maize, barley and gram, however, are rarely used for cattle feeding. Besides, the bran which is a desirable food for animals and which can be much better utilized by them than by humans who would derive little physiological benefit therefrom is used increasingly as a human food.

The total production of oilcakes is hardly 2.3 million tons as compared to 5.8 million tons required to feed only mature working and milch animals. Obviously a wide gap exists between the demand and the acual production. Moreover, when the actual availability of oilcakes to animals is considered, one finds the gap made wider because at one time in recent years almost 50 per cent of the production was being diverted for use directly as manure. In addition, there is a marked tendency on the part of certain planners of food programmes to advocate the use of oilcakes for human consumption,

These encroachments and tendencies portend a sure and gradual deterioration of animal efficiency, which will eventually upset the agricultural balance and thereby all hopes for future recovery in food production. There appears to be, therefore, considerable confusion regarding the direction in which the efforts of Indian workers should be canalized to achieve a reasonably lasting solution of the nation's food problem. The review of the Joint Committee has revealed an almost insurmountable difficulty in attaining the target if the existing agricultural policy and practices are perpetuated. A modified plan for food production has, therefore, been put forward, indicating the extent to which the target of human food requirement could be achieved. A rational method of livestock feeding which can be integrated in the general plan of food production has been elaborated.

The Joint Committee had to keep in view the fact that all foods required for both human beings and animals must come from the land and that animal husbandry is but a means to an end, that end being the improvement in the living standard of the people The planning of animal husbandry is thus directed to the increased efficiency of the animals so that they may contribute directly or indirectly to the welfare of man.

We have already given up-to-date figures on the classes and numbers of livestock in India, including those involved in the production of human foods (Table II). Table V gives an estimate of the requirements of different feeding stuffs for maximum animal production, and Table VI an estimate of the requirements and present supply of these feeding stuffs.

One cannot help feeling more than a little doubtful about these calculations on an all-India basis, although at the same time admitting that they must in the absence of more accurate data be an essential basis to policy-making. They must, however, ultimately be translated down to the level of capacity of the individual farmer. The key problem in this book is how the cultivator with less than five acres of cultivated land (with little or no grazing) can incorporate fodder production into his arable farming system. It has been shown that it is possible in an irrigated holding of five to seven acres, but not yet on a dryland holding of comparable size. This problem urgently requires intensive investigation in all the agricultural zones of India.

Limitation Of Livestock Numbers

With regard to the nature of the livestock population, the Memorandum of the Joint Committee states : "some people seem to believe that a sizeable portion of our animal population is useless and should, therefore, be destroyed," quoting the total number of useless cattle as being only about 4 millions.

It is not our wish to become involved in arguments about the pros and cons of cow slaughter, but a recent questionnaire on the subject has produced an interesting, and perhaps promising result. The questionnaire issued by the Indian Council of Agricultural Research on the draft of the Memorandum under discussion included the question. "Do you agree that the useless and unproductive animals should be eliminated ; if so, what are your proposals ? Should they be allowed to be slaughtered or should they be concentrated in jungle areas and allowed to die a natural death?" The questionnaire went to agriculturists and human nutrition specialists throughout India. There were three main schools of thought ; 46 per cent of those who replied believed there was no alternative expedient for the elimination of useless cattle other than by planned slaughter, 23 per cent regarded slaughter as repugnant and, therefore, advocated placing of useless cattle in concentration camps (*go sadans*), and 13 per cent believed in planned slaughter, but suggested that *go sadans* should be given a trial because of the strong religious prejudice. Of the remainder, 3 per cent recommended the export of useless cattle alive, while 5 per cent recognised the need to eliminate them, but did not state how it might be done.

Against the existing background of negligible slaughter of the cow and the bullock, various attempts are being made to cope with the situation. Castration of scrub bulls and the voluntary denial of service to scrub cows is being carried on energetically in the key villages and in some States, particularly Uttar Pradesh. This will reduce the reproduction rate in the current bovine generation, but the scrub males and females are still in existence to rob feed and grazing from the new generation of genetically superior young animals, which will, in their turn, demand greatly improved nutrition if they are to develop their full potentialities. When these superior young animals are mature, it may be difficult to convince their owners why they should still have the males castrated and not breed from all the females ; the increase of population will begin again, this time of animals even less able to exist on a minimum feed supply than the present.

Meeting The Demand

The animal husbandman and breeder must not expect the grassland manager and crop agronomist to be able to produce adequate grazing and fodder for the existing livestock population. The small proportion of the grassland which can be reached by grazing livestock which have to return to a village each evening, is hopelessly overgrazed and misused and at present has no value in conserving soil and water. In order to promote the cultivation of fodder crops on arable land in place of a proportion of the existing food crop acreage, the crop agronomist should be in a position to argue that the return per acre from fodder crops expressed in livestock products or performance should compare reasonably well with the return from food or cash crops. In some countries it does, but it is very unlikely in India with the present average quality of livestock. Although we must recognize the peculiar economics of village milk production in India (Warner and Joshi, 1943 and Warner in "*Dairying in India*", 1953) it has been stated that an annual milk yield of about 3,500 lb. is the level at which fodder production becomes economic.

Except for a brief period each year during the monsoon, the grasslands of India are of very poor quality ; there is as yet no evidence that their value as animal feed, either cut or grazed, can be much improved by the addition of legumes or that fertilization will be an economic proposition. With proper management, their carrying capacity for a specific period of the year may possibly be improved ; their capacity to protect the soil and reduce run-off and erosion can certainly be greatly increased, but only if the duration of grazing each year is restricted.

In Chapter VII, we review the recommendation of the Joint Committee on Human and Animal Nutrition to the effect that increased emphasis will in future have to be placed on the cultivation of leguminous high-protein fodder. This emphasis will have to be even greater in India than in the humid temperate lands, since the roughages of India (primarily cereal straws and grass hay or straw) are of much poorer quality than the hay crops of Great Britain, Western Europe and other countries. Because most of this high-protein leguminous fodder will have to be carted to the animals in green or conserved form, new types of animal maintenance and husbandry will have to be evolved.

In order both to reverse the process of degeneration of vegetation and the land and the increasing desiccation which is so obvious in Western India, and to

facilitate controlled feeding of livestock, the ultimate objective must be to keep animals off the land and to confine them in some type of corral or exercise ground for the greater part of the year. It may perhaps be hoped that the village cow-keeper may soon become tired of the expense and labour involved in growing and carting feed to poor-quality surplus or otherwise useless animals. Then the cow, which acquired its present position in the Hindu religion for economic reasons, must surely go out also for economic reasons and again become a credit and a strength to the livestock industry of India.

A Final Assessment

At the moment the two sides of the balance sheet cannot be made to agree. The grassland ecologist and fodder agronomist can in the circumstances merely indicate the peculiar natural and other difficulties with which he has to cope in India. This will show in a general way how a certain number of livestock may be maintained in India without causing any further deterioration of the land resources. Even a building up may some day be possible.

In order to arrive at some figures on the grassland resources of India, one would have to use data of the type given in Table VII, in conjunction with the figures given in Tables LXVIII and II. It is not possible to state the total area of grassland in forests but we can state the area actually open to grazing (see column 2 of Table LXIX). As shown in Chapter XI, not all this forest area is grazed, grazing being confined to the more accessible peripheral areas. The main grazing resource, however, is the various types of waste land, part of which are recorded under forests and part under uncultivated und uncultivable area. Under these heads would be included Government and private forests, extensive grassland areas, semi-desert regions, alkaline land, village pastures and grazing lands.

Administrators and others not fully informed on the complexity of the problem may expect the grassland ecologist to state at least the approximate carrying capacity of the grassland of the country on an All-India or State basis. It is difficult, if not impossible, to give any figures which would have a sufficiently sound practical or statistical basis to mean anything. The grazing lands vary widely in type and degree of current use and misuse. Some areas are inaccessible to village livestock, others near centres of population are completely ruined by year-round grazing of excessive numbers of livestock.

It is shown elsewhere that good-quality livestock, which should presumably be the objective of the animal husbandmen, cannot be maintained in good con-

dition on the Indian grazing lands alone. In fact, most Indian grasses are inadequate for dairy livestock during the greater part of the year. In certain months, during and just after the monsoon, average cattle may obtain much of their sustenance from grazing. Thereafter, the natural grass deteriorates in nutritive value and can no longer contribute anything of value to the ration ; at the same time the botanical composition and hence the quality of the grassland itself deteriorate if used throughout the year, the danger period being in general from January/February until the next monsoon.

If quality livestock are to be fed on an uniform plane of nutrition throughout the year, a properly designed pasture and fodder calendar must of necessity cater for a balanced supply of nutriment from grassland, fodder crops, crop residues and other sources of feed. It is not possible to utilize grassland for grazing correctly during a specified period of the year without having available the necessary acreage to provide the other types of fodder which will supplement the grassland during the grazing months and replace it during the remaining months. A reference to the fodder crop acreage in India (Table IV) will show how much of this supplementary feed must at the moment be obtained from crop residues.

There is an urgent need for work on carrying capacity per grass plus fodder acre to be done at animal husbandry farms, to provide data something on the lines of those reported in Chapter VIII. The data on grassland should be obtained in association with a grassland ecologist, who should be in a position to indicate whether the botanical composition of a grazed area is deteriorating, being maintained, or improving under the treatment it is receiving. The animal husbandry officers should also collaborate with the fodder agronomist who should be in a position to state the type and quality of feeds which can be provided from the cultivated land, and the months during which it is available in a fresh or conserved condition. The evidence does not at the moment exist for an assessment of supply and demand on an All-India basis.

TABLE II

Comparative data for number of livestock and poultry in India, 1945 and 1951

(In thousands)

Categories of Livestock/Poultry	1951				1945			
	Part 'A' States	Part 'B' States	Part 'C' States	Total India	Part 'A' States	Part 'B' States	Part 'C' States	Total India
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total cattle	112,712	35,795	6,592	155,099	98,480 (a)	31,645	5,835	135,950 (a)
1. Males over 3 years	47,067	12,371	2,321 (a)	61,759 (a)	42,222 (c)	11,077 (b)	1,975 (c)	55,274 (d)
(i) Breeding	481	102	63	646	437	89	17	543
(ii) Working	44,524	11,739	2,150	58,413	39,954	10,569	1,609	52,132
(iii) Others	2,062	530	107	2,699	1,559	414	77	2,050
2. Females over 3 years	34,918	12,506	2,424 (a)	49,848 (a)	30,421 (e)	10,795 (f)	2,145 (g)	43,361 (h)
(i) Breeding								
(a) In milk	13,534	4,481	938	18,953	11,954	4,290	763	17,007
(b) Dry and not calved	18,683	7,343	1,360	27,386	16,195	6,046	1,027	23,268
(ii) Working	1,761	504	49	2,314	1,281	338	27	1,646
(iii) Others	940	178	76	1,194	563	112	40	715
. Young Stock	30,727	10,918	1,847	43,492	25,836	9,773	1,715	37,324

Total buffaloes :	31,727	10,250	1,367	43,351	29,450 (a)	9,858	1,285	40,593 (a)
1. Males over 3 years	5,805	851	122 (a)	6,778 (a)	4,876 (i)	774 (a)	98 (j)	5,748 (k)
(i) Breeding	224	67	15	306	192	66	13	271
(ii) Working	5,180	726	100	6,066	4,422	668	69	5,159
(iii) Others	401	58	6	465	242	39	9	290
2. Females overs 3 years	15,632	5,414	796 (a)	21,842 (a)	14,214 (l)	4,985 (m)	729 (n)	19,928 (o)
(i) Breeding—								
(a) In milk	7,324	2,564	329	10,217	7,650	2,699	299	10,648
(b) Dry and not calved	7,592	2,738	446	10,776	6,071	2,188	307	8,566
(ii) Working	473	50	10	533	327	52	17	396
(iii) Others	243	62	10	315	142	40	10	192
3. Young Stock	10,297	3,985	449	14,731	10,359	4,099	458	14,916
Total sheep	22,528	14,937 (p)	1,364	38,829 (p)	18,649 (q)	17,462 (r)	1,618 (s)	37,729 (t)
(i) One year and above	19,282	11,410	1,099	31,791	13,995	13,577	1,181	28,753
(ii) Below one year	3,246	1,679	265	5,190	3,706	3,882	363	7,951
Total goats	32,906	12,501 (v)	1,670	47,077 (v)	28,509 (v)	15,902 (l)	1,875 (n)	46,286 (w)
(i) One year and above	26,444	9,460	1,335	37,239	19,619	11,363	1,327	32,309
(ii) Below one year	6,462	1,990	335	8,787	7,025	4,515	452	11,992
Total horses and ponies	999	454 (x)	61	1,514 (x)	856 (a)	475	68 (y)	1,399 (r)
(i) 3 years and above	677	239	47	963	681	347	55	1,083
(ii) Below 3 years	322	124	14	460	174	128	11	313
Mules	45	10	5	60	30	11	4	45
Donkeys	789	418	32	1,239	668	433	31	1,132
Camels	188	429	12	629	176	458	20	654

TABLE II—(*contd.*)

Comparative data for number of livestock and poultry in India, 1945 and 1951

(*In thousands*)

Categories of livestock/poultry	1951				1945			
	Part 'A' States	Part 'B' States	Part 'C' States	Total India	Part 'A' States	Part 'B' States	Part 'C' States	Total India
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pigs ...	3,730	478	212	4,420	3,167	409	131	3,707
Total Livestock ...	205,631	75,272	11,315	292,218	179,985	76,653	10,867	267,505
Total Poultry ...	60,370	11,793 (z)	1,258	73,421 (z)	45,170	12,201	868	58,239
Fowls ...	54,652	11,355	1,128	67,135	41,907	11,911	838	54,656
Ducks ...	5,718	416	130	6,264	3,263	290	30	3,583

(a) Includes 1 thousand for which details are not available.
(c) do. 272 do. do. do.
(e) do. 428 do. do. do.
(g) do. 288 do. do. do.
(i) do. 20 do. do. do.
(k) do. 28 do. do. do.
(m) do. 6 do. do. do.
(o) do. 126 do. do. do.
(q) do. 948 do. do. do.
(s) do. 74 do. do. do.
(u) do. 1,304 do. do. do
(w) do. 1,985 do. do. do.
(y) do. 2 do. do. do.

(b) Includes 5 thousand for which details are not available
(d) do. 549 do. do. do.
(f) do. 9 do. do. do.
(h) do. 725 do. do. do.
(j) do. 7 do. do. do.
(l) do. 24 do. do. do.
(n) do. 96 do. do. do.
(p) do. 1,848 do. do. do.
(r) do. 3 do. do. do
(t) do. 1,025 do. do. do.
(v) do. 1,051 do. do. do.
(x) do. 91 do. do. do.
(z) do. 22 do. do. do.

Figures for 1945 and 1951 censuses are not comparable *inter se* due to the increase in the reporting areas.

TABLE III

Estimated livestock products

(Based on 1951 livestock census)

Products	Amounts
Ghee and butter :	*Lakh maunds*
Ghee	117.27
Butter	20.35
Milk	5,203.38
Meat :	*Tons*
Beef	95,847.0
Buffalo flesh	73,976.7
Mutton	112,150.0
Goat flesh	155,638.3
Pork	23,633.2
Total	461,245.2
Skins :	*Lakhs*
Goat	212.94
Sheep	155.04
Total	367.98

TABLE

Relation between number of bovines and areas

States	Bovine population (in thousands)	Cultivable area (in thousand acres)	Gross area sown (in thousand acres)	Net area actually sown (in thousand acres)
1	2	3	4	5
Assam	5,620	7,309	6,393	5,570
Bihar	18,613	27,585	29,133	22,848
Bombay	16,077	48,125	42,363	41,082
Madhya Pradesh	17,459	33,375	32,194	28,456
Madras	27,283	41,024	36,345	31,308
Orissa	8,782	13,993	15,436	12,154
Punjab	6,844	13,328	14,136	11,948
Uttar Pradesh	32,764	42,341	49,319	39,779
West Bengal	11,004	12,879	13,011	11,720
Hyderabad	11,742	37,183	24,199	24,064
Jammu and Kashmir	1,604	1,962	1,664	1,556
Madhya Bharat	7,919	11,861	11,440	10,752
Mysore	5,778	8,353	6,861	6,656
PEPSU	2,289	4,991	4,790	4,115
Rajasthan	13,411	18,647	17,407	16,489
Saurashtra	1,824	4,350	3,690	3,540
Travancore Cochin	1,477	2,894	3,065	2,826
Ajmer	417	616	406	369
Bhopal	887	1,658	1,608	1,551
Bilaspur	113	90	120	75
Coorg	168	205	171	170
Delhi	164	236	274	225
Himachal Pradesh	1,190	622	911	562
Kutch	334	2,207	764	741
Manipur	162	220	207	207
Tripura	218	401	457	387
Vindhya Pradesh	4,300	5,108	4,850	4,062
Andaman and Nicobar Islands	7	12	9	9
Total	198,450	342,075	321,223	283,221

(b) Below 500 acres

IV

under cultivation and fodder crops respectively

Total area under fodder crops (in thousand acres)	Fodder acreage expressed as percentage of gross area sown	Number of bovine per cultivable acre	Number of bovines per gross area sown	Number of bovines per net area sown	Number of bovines per acre of fodder crops
6	7	8	9	10	11
26	0.4	0.7689	0.8791	1.0089	216.1538
N. A.	...	0.6748	0.6389	0.8146	...
4,256	10.0	0.3341	0.3795	0.3913	3.775
458	1.4	0.5231	0.5423	0.6135	38.1201
481	1.3	0.6650	0.7507	0.8714	56.7214
73	0.4	0.6276	0.5689	0.7226	120.3013
1,998	14.1	0.4949	0.4842	0.5728	3.4254
1,756	3.5	0.7738	0.6643	0.8237	18.6583
7	0.05	0.8544	0.8457	0.9389	1572.0000
43	0.2	0.3158	0.4852	0.4879	273.0697
26	1.6	0.8175	0.9639	1.0308	61.6923
36	0.3	0.6676	0.6922	0.7365	219.9722
204	3.0	0.6917	0.8422	0.8681	28.3235
701	14.6	0.4586	0.4779	0.5563	3.2653
1,097	6.3	0.7192	0.7704	0.8133	12.2252
27	0.7	0.4193	0.4943	0.5153	67.5556
45	1.5	0.5104	0.4819	0.5226	32.8222
9	2.2	0.6769	1.0271	1.1301	46.3333
276	17.1	0.5350	0.5516	0.5719	3.2137
(b)	...	1.2556	0.9417	1.5067	...
...	...	0.8195	0.9825	0.9882	...
34	12.4	0.6949	0.5985	0.7289	4,8235
2	0.2	1.9132	1.3063	2.1174	595.0000
210	27.5	0.1513	0.4372	0.4507	1.5905
...	...	0.7364	0.7826	0.7826	...
...	...	0.5436	0.4770	0.5633	...
55	1.1	0.8418	0.8966	1.0586	78.1818
...	...	0.5833	0.7778	.778	...
11,820		0.5801	0.6177	0.7006	16.7893

Table V

Total requirement (in million tons) of different feeding stuffs for maximum animal production
(*Sen, 1953*)

Feeding stuffs	*Milch stock*		*Laying birds*		Meat producers	*Followers*			
	Maintenance	Production	Maintenance	Production		Work Stock	Animal	Bird	Total
Roughage									
Straw or *kadbi*	71	*Nil*	*Nil*	*Nil*	22	81	16	*Nil*	190
Green fodder	239	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	50	*Nil*	289
Grazing (as green grass)	119	*Nil*	50	*Nil*	102	132	25	25	453
Concentrates									
Oilcakes	*Nil*	2·58	0·70	0·96	0·55	2·94	2·14	0·35	10·22
Maize	*Nil*	2·26	*Nil*	*Nil*	*Nil*	3·68	2·93	*Nil*	8·87
Barley	*Nil*	2·26	*Nil*	*Nil*	2·48	3·67	*Nil*	*Nil*	8·41
Gram	*Nil*	2·26	*Nil*	*Nil*	2·41	1·47	2.10	*Nil*	8·24
Cottonseed	*Nil*	2·26	*Nil*	*Nil*	*Nil*	1·47	*Nil*	*Nil*	3·73
Bran	*Nil*	1·29	0·70	0·96	*Nil*	1·47	0·06	0·35	4·83
Cereal grains	*Nil*	*Nil*	16·84	2·16	*Nil*	*Nil*	*Nil*	8·42	27·42
ish meal or meat offal	*Nil*	*Nil*	0·52	0·72	*Nil*	*Nil*	*Nil*	0·26	1·50

TABLE VI

Estimated requirements and the present-day supply of feeding stuffs (in million tons) (Sen, 1953)

Feeding Stuffs	Estimated requirement	Present Supply*	Deficit or surplus
Straw or *kadbi*	190	130	− 60
Green fodder	289	111	− 178
Grazing (as green grass)	453	527	− 74
Oilcakes	11·53	2·88	− 8·65
Maize	8·87	1·70	− 7·17
Barley	8·41	2·34	− 6·07
Gram	8·24	3·59	− 4·65
ottonseed	3·73	1·28	− 2·45
Bran	4·83	1·97	− 2·86

*In addition, about 1·24 million tons of husk—*chuni* from gram and pulses—are available, having a nutritive value approximately the same as that of bran. This material, therefore, can relieve the shortage of bran to the proportional extent.

Table VII

Total area and classification of area

1951-52

In thousand acres

State	Total geographical area according to Surveyor-General of India		Forest	Area under agricultural use (net area plus current fallows)	Uncultivated and uncultivable area excluding the area occupied under buildings, roads, railways and under water		
		†			*	**	%%
Andhra	40,711	40,602	8,131	17,932	11,696	14,539	...
Assam	54,408	35,764	***	5,499	‡‡	22,908	3,156
Bihar	45,011	44,790	8,571	25,450	7,352	10,769	...
Bombay	71,213	70,299	10,860	44,236	14,134	15,203	...
Madhya Pradesh	83,375	82,983	32,764	29,434	‡‡	20,785	...
Madras	38,632	38,452	5,925	18,920	10,095	13,607	...
Orissa	38,498	38,498	7,163	15,921	12,556	15,414	...
Punjab	23,922	23,921	742	13,800	8,743	9,379	...
Uttar Pradesh	72,597	72,279	7,866	40,957	15,018	23,456	...
West Bengal	19,696	19,618	1,712	11,730	‡$	6,176	...
Hyderabad	52,572	50,606	4,931	32,692	11,002	12,983	...
Jammu and Kashmir	59,379	5,997	***	1,911	1,840	2,597	...
Madhya Bharat	29,785	27,813	2,915	11,393	10,837	13,505	...
Mysore	21,316	19,923	***	9,354	6,560	8,324	...
PEPSU	6,431	6,370	47	5,033	848	1,290	...
Rajasthan	83,327	76,333	3,274	27,599	42,665	45,460	...
Saurashtra	13,655	5,849	***	3,540	‡‡	2,130	..
Travancore Cochin	5,852	5,351	***	2,804	795	1,010	...
Ajmer	1,547	1,549	98	601	836	850	...
Bhopal	4,400	4,406	1,342	1,665	1,222	1,399	
Bilaspur	290	285	32	79	174	174	...
Coorg	1,015	1,012	331	191	440	490	...
Delhi	370	366	***	241	50	125	...
Himachal Pradesh	6,692	2,006	***	620	945	1,014	...

Table VII—(*contd.*)

Total area and classification of area

1951-52

In thousand acres

State	Total geographical area according to Surveyor-General of India		Forest	Area under agricultural use (net area plus current fallows)	Uncultivated and uncultivable area excluding the area occupied under buildings, roads, railways, and under water		
Kutch ...	10,864	10,864	127	883	‡‡	9,854	...
Manipur ...	5,518	346	37	203	‡‡	106	...
Tripura ...	2,580	2,634	***	451	507	551	...
Vindhya Pradesh ...	14,837	14,837	***	5,109	7,722	8,392	...
Andaman and Nicobar Islands ...	22,058	78	36	12	25	30	...
Total ...	810,809	703,831	109,895	328,260	166,102	262,519	3,156

Forest : These include all actually forested areas on the lands classed or administered as forests under any legal enactment dealing with forest whether State owned or private.

*** Complete statistics not available.

Area under agricultural use : These include the net area sown and current fallow.

* These include barren and uncultivable land, permanent pastures and other grazing, culturable waste, fallow land, miscellaneous area under groves and tree crops, etc., and exclude land under buildings, roads, railways and under water (rivers and canals).

† Area according to village papers (*i.e.* reporting area).

‡‡ Area not available separately.

** Uncultivated and cultivable area including the area under buildings, roads, railways, and area under water, etc.

%% Area for which details are not available.

Note : 1. The land classification has been taken on the basis of figures from village papers. These figures differ from those of Surveyor-General of India. The difference seems to be due to unsurveyed areas which are mostly inaccessible, rocky and hilly portions and which have not been included in the village papers.

2. As Andhra was a part of Madras State in 1951-52, the period to which these figures relate, the figures received from Madras State were split up in I. C. A. R. for Andhra and Madras separately.

CHAPTER IV

FEED RESOURCES AND QUALITY

MUCH has still to be learnt about the botanical composition and applied ecology of Indian grasslands and about the methods of cultivating fodder crops in rotation with food and cash crops. The specialists in animal nutrition and analytical chemistry have, however, in the meantime provided a wealth of data on the chemical composition and nutritive value of Indian grasses, legumes, crop residues, concentrates, tree leaves and the numerous other miscellaneous types of fodder.

In 1921, Dr F. J. Warth, then Physiological Chemist, began to investigate animal feeds at the Imperial Agricultural Research Institute, Pusa, Bihar. In 1923, the section was transferred to Bangalore, where it formed one of the two wings of the new Imperial Institute of Animal Husbandry and Dairying. In the same year, Dr P. E. Lander and his associates began their study of the nutritive value of various North Indian feeds at Lyallpur, which was continued by Dr Lal Chand Dharmani, first at Lyallpur and then after partition and up to his retirement at Ludhiana, Punjab.

When Dr Warth retired in 1935, his section was transferred to Izatnagar to become the Division of Animal Nutrition of the Indian Veterinary Research Institute. Dr K. C. Sen extended the work to cover the physiological, biochemical and pathological aspects of the subject until his appointment in 1944 as Director of the Indian Dairy Research Institute at Bangalore. Dr N. D. Kehar then became and still is in charge of the Animal Nutrition Laboratory at Izatnagar.

Work in the States included the studies of the nutritive value of rice straw by Chatterji and his associates at Dacca (now East Pakistan), on the chemical composition and particularly the low phosphorus content of indigenous fodders by Ramiah and his associates at Coimbatore, Madras, on the nutritive value of lucerne and berseem by Das Gupta and his associates at Bharari, Jhansi, Uttar Pradesh and on the feeding value of straws of common pulses. In 1943, an Animal Nutrition Section was established at the Agricultural Institute at

Anand, Bombay, and work began on the effect of various feeds on the quality of milk.

There is need for more research on questions such as the relation between nutritive value and environment ; nutritive values may differ widely between one set of soil/climatic conditions and another. Rations suitable for different types, breeds and ages of livestock have to be evolved for different parts of the country. The seasonal trends in feeding values of natural and cultivated grasses and legumes need to be studied.

Overall Picture

We have already given a general statement on this aspect in Chapter III, but here we will state it again in the terms of the nutrition chemist, as presented by Kehar (1953). Only an approximation can be attempted in the absence of reliable data on an all-India basis.

Table VIII

Feeds available from various sources
(in million tons)
[*Kehar, 1952*]

Feeds	Available amount on dry matter basis	Digestible protein	Starch equivalent
Fodder crops	36·1	1·8	18·0
Grasses	...	3·4	33·0
Straw	93·0	0·5	23·3
Oilcakes	3·2	0·9	2·1
Bran	1·5	0·1	0·8
Pulse (husk and straw)	1·5	0·1	0·7
Cotton-seed	1·4	0·2	1·0
Milk (consumed by calves)	1·0	...	0·6
Total	...	7·0	79·5

In calculating the requirement of bovines alone, Kehar assumes that 40 per cent of the cows are in milk and produce an average of 5 lb. milk per cow and 10 lb. milk per buffalo-cow per day, that the calves gain at the rate of 1 lb. per day, and that the bullocks work at the rate of four hours per day. The total annual requirement of the bovine stock would then be 26 million tons of digestible crude protein and 206 million tons of starch equivalent, calculated on the basis of Western data. Kehar and Mukherjee (1944) have shown that the maintenance requirement of Indian cattle is 25 per cent lower than that recommended by Morrison. If one disregards equines, sheep, goats, poultry and pigs, practically all of which are under present conditions expected to find their feed by free-range grazing and foraging, the requirements for India's present bovine population may be said to be 30 million tons of digestible crude protein and 210 million tons of starch equivalent. The present supplies are 23 per cent and 38 per cent respectively of the required amounts.

Although calculations of this kind based on such inadequate data cannot be statistically reliable, they do give an approximate indication of the feed deficiencies in India. The great lack of fodder has caused the stock population to rely entirely on the pastures within reach of centres of population and which the livestock themselves have in most cases ruined, on straws and similar residues of human food crops and on the small amounts available of leguminous grains, cottonseed cakes and other concentrate feeds. Although regional and local shortages of human food can be met by transference of stocks and by importation, bulky dry roughages or green fodders cannot be transported physically or economically far from the place where they are produced or grow naturally.

The Crop Zones

From an animal feeding point of view it is convenient to utilise the division of India into three major crop zones, with the following characteristics :

A. *Paddy zone.* Assam, Bengal and part of Madras. The soil is deficient in nitrogen, organic matter and not infrequently in lime. It responds to phosphatic and organic manures. The average annual rainfall is above 70 inches.

B. *Millet zone.* Bihar, Orissa, Madhya Pradesh, part of Uttar Pradesh and parts of Madras and Bombay. The soil is better in comparison, apart from some mineral-deficient areas in Bihar and Uttar Pradesh. The average annual rainfall is 30 to 70 inches.

C. *Wheat zone.* North and northwest of India, particularly parts of Uttar Pradesh

and Punjab. The alluvial soils have adequate organic matter, nitrogen, calcium and phosphorus except in a few deficient areas. Rainfall is up to 30 inches, sometimes unreliable between one season and another.

The average weights of adult bovines in these three zones are 500, 600 and 700 lb. respectively. If one assumes that the bulky fodder requirement of non-producing animals is 17·5 lb. per 1,000 lb. body weight and that the maintenance requirement of a 1,000 lb. animal could be met by about 1 lb. of concentrate when green and dry roughages are fed, very serious quantitative deficiencies may be noted in the three zones.

The roughage supply in Zones A and B is not sufficient in quantity to meet the needs of adult bovines, disregarding all other classes of livestock. The deficiencies in concentrates in Zones A, B and C are of the nature of 75, 70 and 45 per cent respectively.

The feeds and fodders of Indian livestock are also deficient in quality. Cereal straws constitute more than 50 percent of the total roughage in Zones A and B, rather less in Zone C. But straws are low in protein (about 3 per cent), and their calcium and phosphorus contents are only 0·40 and 0·15 per cent respectively, as compared with 8·0, 0·60 and 0·40 per cent protein, phosphorus and calcium for an average sample of non-leguminous cultivated fodder and pasture grass cut at the flowering stage.

An estimate made some years ago of the number of adult bovines per acre of cultivated fodder crop in the three Zones gave figures of 52, 19 and 3 respectively, (see, however, Table IV). The pressure of bovine population per cultivated acre in Zones A and B is double of that in Zone C. The average cultivator is extremely poor and unable to feed his degenerate 'nondescript' livestock properly or to replace them with a better type of animal. He is, therefore, compelled to keep an increasing number of low-producing animals in order to meet his normal demands for cattle labour and dairy produce. "Thus the inefficiency of the farm animals in India, their enormous number and the precarious feed situation are inextricably linked in a vicious circle" (Kehar, 1946).

Chemical Composition In General

All the available data on this subject have been summarised by Sen (1952). Three appendices to his Bulletin deal with the average percentage

composition of Indian feeding stuffs on a dry matter basis, their average digestibility coefficients and their nutritive value expressed as digestible nutrients per 100 lb. dry and raw material respectively.

For the purpose of this book, we quote in Table IX only some of the data from the first appendix in so far as they affect the more common grasses, legumes, crop residues and other feeds to which frequent reference is made in other Chapters. Only the mineral constituents, CaO and P_2O_5, have been included, ash soluble in HCl, MgO, Na_2O and K_2O being omitted for reasons of space.

Particular notice should be taken of the protein content of the grasses and the cereal straws. The latter have generally around 3 per cent protein. Some of the grasses, and especially *Cenchrus ciliaris* (*anjan*) and *Cynodon dactylon* (*doob*), which grow more particularly in Northwest India, show reasonably good protein contents in the young state. Most species have, however, a relatively high protein content for a very short period only in the latter part of the monsoon, generally in late August or early September. Thereafter they deteriorate rapidly with increasing maturity. The great majority of Indian cattle, therefore, subsist for most of the year on a grazing or straw diet which is around the 3 and 5 per cent protein mark. This is why emaciated indigenous cattle recover so much condition on grass alone during the monsoon period. It has been found possible to maintain non-producing animals in prime condition for a large part of the year in areas where good quality *anjan* or *doob* grows.

Apart from the protein content, the straws and mature grass hays commonly available in India are practically devoid of vitamin A potency (Sen, 1952); this also applies to most of the concentrates. For this reason, avitaminosis-A in a mild form is widely prevalent and occasional indications of this deficiency, such as intra-uterine blindness, ophthalmia in growing animals, abortion and sterility, are found in many places.

Studies In The Punjab

Lander and his associates (1942) made important studies in pre-partition Punjab, which indicate the general trends of quality in relation to soil, climate and botanical composition of the herbage. Some areas in this State are noted for the richness of the natural fodder and the excellence of the livestock which graze it, others are very poor.

The curve of increasing lime content in the soil given in figure 2 of Lander (1942) follows the course taken by the rivers in the Punjab, the soils in the north-western dry area being much richer in lime than those in the trans-Gangetic plains or even in the sub-montane tract. The soils in the hilly tracts of the Kangra district show a very small percentage of lime. The quantity of magnesium in the Punjab soils does not vary so widely. These soils are not deficient in potash (0.72 per cent in the top soil, 0.66 per cent in the sub-soil). The highest phosphoric acid contents were found in two samples, 1.36 and 1.6 per cent respectively. These figures are, however, abnormal, as the phosphoric acid content of most Punjab soils is between 0.1 and 0.3 per cent ; the average of 154 samples is 0.18 in the top-soil and 0.16 in the sub-soil.

Lander (1942) investigated certain composite hays obtained from Military Grass and Dairy Farms. Complete chemical and mineral analyses are corrected with the data obtained from elaborate digestibility trials.

Hays from Sialkot (plains) and Murree (hills) have protein contents of 4.83 and 3.68 per cent, yet the digestibility co-efficients for their respective proteins are 40.18 and 15.84 per cent. Although this may be explained on the basis of the nature of proteins and their corresponding digestibilities, Lander draws attention to the phosphoric acid contents of these two hays, 0.43 and 0.11 per cent respectively. The digestible protein per 100 lb. of the Sialkot hay is 2.17, that of the Murree hay 0.56. These and other figures are taken as indicating a possible relationship between mineral content and the availability of other nutrients in the feed.

Analyses of a number of Punjab grasses are important in relation to the selection of species which may deserve special attention by the plant breeder, and in indicating how correct grassland management of certain species may help them to retain a high nutritive value. Unfortunately most of the analyses were made of plant material grown under cultivated irrigated conditions and are not perhaps directly applicable to plant material from the uncultivated land where they would normally be found.

Anjan (*Cenchrus ciliaris*) is one of the richest grasses found in India : its composition at different stages of growth in two consecutive years is shown in Table XV and XVI. There is a variation in protein, calcium and phosphoric acid contents, with the samples from Lyallpur (now West Pakistan) being conspicuously rich.

TABLE

Average percentage composition of certain Indian

No.	Botanical name	Common name	Stage of harvest
1	*Pennisetum typhoideum*	*Bajra*	Just before flowering
2	do.	do.	Maximum flowering
3	do.	do.	Dough stage
4	do.	do.	Milk stage
5	do.	do.	Ripe stage
6	do.	do.	Milk dough stage
7	*Trifolium alexandrinum*	Berseem	
8	do.	do.	Maximum
9	do.	do.	Minimum
10	do.	do.	Average
11	*Vigna catiang*	Cowpea	
12	*Cenchrus ciliaris*	*Anjan*	Young
13	do.	do.	Prime
14	do.	do.	Ripe
15	do.	do.	Young
16	do.	do.	Prime
17	do	do.	Ripe
18	do.	do.	Maximum
19	do.	do.	Minimum
20	do.	do.	Average
21	do.	do.	Young
22	do.	do.	Prime
23	do.	do.	Ripe
24	*Dichanthium annulatum*	*Barajergi*	1st cut
25	do.	(*Marvel*)	2nd cut
26	do.	do.	3rd cut
27	*Apluda mutica*	*Bhanjura*	1st cut

IX

feeding stuffs on dry matter basis (Sen, 1952).

Place of origin	Total ash	Ash sol. in HCl	Organic constituents		Carbohydrates		CaO	P_2O_5
			Crude protein	Fibre	Nitrogen free extract	Ether extract		
Punjab	14.70	10.90	16.25	28.23	38.79	2.03	1.06	0.42
do.	11.30	8.61	12.56	28.45	45.72	1.97	0.84	0.48
do.	9.21	6.28	10.56	27·96	50.15	2.12	0.73	0.50
do.	8.21	5.40	8.81	24.90	56.22	1.86	0.60	0.39
do.	7.68	5.09	8.88	23.96	57.74	1.74	0.55	0.44
Lyallpur	...	...	6.90	31.80	48.90	1.52	...	...
Bihar	20.25	12.99	15.45	26.06	35.88	2.36	2.33	0.75
Punjab	18.96	14.43	23.10	30.87	46.94	2.78	4.05	0.92
do.	8.49	7.07	13.99	19.47	33.24	1.39	2.20	0.32
do.	14.16	12.00	17.35	25.91	40.69	1.89	2.69	0.64
Bihar	10.86	6.80	17.38	33.10	36.16	2.50	1.96	0.78
Bangalore	13.82	9.23	12.41	...	...	...	0.41	0.65
do.	11.57	6.61	9.97	...	...	...	0.49	0.47
do.	10.26	4.93	7.25	...	...	...	0.43	0.39
Bihar	17.05	9.42	7.40	...	...	...	0.75	0.64
do.	13.45	7.06	8.18	...	...	...	0.72	0.50
do.	13.71	6.00	5.54	...	...	...	0.63	0.69
Punjab	20.85	10.96	12.02	43.62	56.84	2.30	1.90	1.05
do.	9.14	3.63	3.00	25.30	39.00	0.97	0.43	0.41
do.	16.08	8.14	8.36	30.54	43.30	1.72	0.77	0.72
do.	18.10	9.60	11.42	27.20	41.41	1.87	0.70	0.85
do	13.31	6.45	6.24	34.43	44.55	1.47	0.67	0.61
do.	15.85	8.73	9.10	29.16	44.29	1.60	0.60	0.65
Bareilly	11.85	...	5.49	31.37	49.66	1.63	0.52	0.55
do.	9.91	...	3.79	35.03	50.09	1.18	0.40	0.49
do.	10.13	...	2.73	33.30	52.84	1.09	0.50	0.35
Bareilly	18.53	...	10.23	32.29	36.96	1.99	0.52	0.93

No.	Botanical name	Common name	Stage of harvest
28	*Apluda mutica*	*Bhanjura*	2nd cut
29	do.	do.	3rd cut
30	*Bothriochloa pertusa*	*Chhoti jergi*	1st cut
31	do.	do.	2nd cut
32	do.	do.	3rd cut
33	*Cynodon dactylon*	*Doob*	
34	do.	do.	Young
35	do.	do.	Prime
36	do.	do.	Ripe
37	do.	do.	Young
38	do.	do.	Prime
39	do.	do.	Ripe
40	do.	do.	Maximum
41	do.	do.	Minimum
42	do.	do.	Average
43	do.	do.	Young
44	do.	do.	Prime
45	do.	do.	Ripe
46	*Panicum maximum*	Guinea	Maximum
47	do.	do.	Minimum
48	do.	do.	Average
49	do.	do.	Young
50	do.	do.	Prime
51	do.	do.	
52	do.	do.	
53	do.	do.	
54	*Chrysopogon montanus*	*Goria*	1st cut
55	do.	do.	2nd cut

Place of origin	Total ash	Ash sol. in HCl.	*Organic constituents*		*Carbohydrates*		CaO	P_2O_5
			Crude protein	Fibre	Nitrogen free extract	Ether extract		
Bareilly	10.91	...	4.56	33.63	49.72	1.18	0.44	0.66
do.	12.13	...	4.06	40.15	41.97	1.69	0.49	0.57
Bareilly	12.31	...	5.44	36.49	44.63	1.23	0.55	0.52
do.	11.32	...	3.86	35.68	48.01	1.13	0.47	0.41
do.	11.28	...	3.19	36.50	47.76	1.27	0.60	0.69
Bangalore	11.74	6.82	12.72	31.00	42.42	2.12	...	...
do.	13.54	7.84	14.75	...	...	...	0.81	0.58
do.	11.91	6.08	11.07	..	...	...	0.70	0.51
do.	9.31	4.85	8.44	...	...	...	0.41	0.28
Bihar	15.07	9.94	7.61	...	...	...	1.07	0.41
do.	13.10	6.71	7.74	...	...	...	0.90	0.44
do.	10.72	5.26	5.81	...	...	...	0.72	0.45
Punjab	13.97	7.38	21.94	39.74	55.40	2.71	0.98	0.82
do.	7.79	2.27	4.90	18.63	41.97	1.21	0.50	0.23
do.	11.75	5.60	10.47	28.17	47.81	1.80	0.77	0.59
do.	12.58	6.20	21.94	18.63	44.14	2.71	0.81	0.82
do.	12.65	5.69	10.04	31.89	44.00	1.42	0.81	0.63
do.	7.79	2.27	4.90	39.74	46.07	1.50	0.50	0.23
Bangalore	10.07	10.09	13.96	41.76	49.96	2.66	0.85	0.16
do.	11.39	5.89	4.73	31.59	35.57	0.66	0.54	0.21
do.	13.87	7.25	7.69	37.33	39.44	1.67	0.71	0.56
do.	15.54	8.55	7.88	38.38	37.01	1.19	0.71	0.90
do.	12.32	6.31	4.82	42.14	40.06	0.66	0.54	0.72
Bengal	13.94	5.88	7.97	32.36	43.99	1.73	1.23	0.54
Punjab	12.15	...	5.22	36.38	44.70	1.25	...	...
Madhya Pradesh	...	...	...	...	...	...	1.81	0.59
Saharanpur	9.73	...	6.13	36.84	46.05	1.25	0.45	0.39
do.	8.73	...	4.64	36.67	48.78	1.18	0.51	0.41

TABLE IX (contd.)

No.	Botanical name		Common name	Stage of harvest
56	*Chrysopogon montanus*	...	*Goria*	3rd cut
57	*Iseilema wightii*	...	No common name	Early
58	do.	...		Before flower
59	do.	...	do.	In flower
60	do.	...	do.	In seed
61	*Iseilema laxum*	...	*Musel*	Before flower
62	do.	...	do.	In flower
63	do.	...	do.	In seed
64	do.	...	do.	
65	*Andropogon pertusus*	...	*Palwan*	
66	do.	...	do.	Flowering stage
67	do.	...	do.	Pre-milk stage
68	do.	...	do.	Milk stage
69	do.	...	do.	Ripe stage
70	*Bothriochloa intermedia*	...	*Sandhaur*	1st cut
71	do.	...	do.	2nd cut
72	do.	...	do.	3rd cut
73	*Andropogon sorghum*	...	*Juar*	Young
74	do.	...	do.	Prime maximum
75	do.	...	do.	Prime minimum
76	do.	...	do.	Prime average
77	do.	...	do.	Prime ripe
78	do.	...	do.	Age: 9-10 weeks
79	do.	...	do.	Age: 18 weeks
80	do.	...	do.	Young
81	do.	...	do.	Prime
82	do.	...	do.	Ripe
83	*Medicago sativa*	...	Lucerne	Maximum

Place of origin	Total ash	Ash sol. in HCl.	*Organic constituents*		*Carbohydrates*		CaO	P_2O_5
			Crude protein	Fibre	Nitrogen free extract	Ether extract		
Saharanpur	10.78	...	4.45	31.60	51.59	1.58	0.65	0.20
Bombay	10.22	4.54	6.02	36.62	45.76	1.38	0.39	0.33
do.	10.31	3.61	4.21	38.87	45.59	1.02	0.37	0.15
do.	9.41	3.61	4.08	41.09	44.32	1.10	0.38	0.20
do.	10.55	2.87	3.21	37.39	47.73	1.12	0.46	0.16
Bombay	11.64	4.03	5.06	34.24	47.70	1.36	0.49	0.17
do.	9.85	2.97	3.69	38.79	46.68	0.99	0.50	0.16
do.	11.80	2.51	2.79	34.52	49.79	1.10	0.59	0.29
Madhya Pradesh	...	...	...	...	...	...	0.79	0.22
Punjab	10.42	5.87	8.78	33.00	46.13	1.67	0.46	0.80
do.	9.10	2.86	4.74	41.09	43.76	1.31	0.78	0.56
do.	10.01	3.31	3.14	35.20	50.54	1.11	0.47	0.29
do.	10.94	4.96	4.72	40.71	42.30	1.33	0.61	0.32
do.	9.82	3.06	4.81	36.27	48.31	0.79	0.69	0.47
Bareilly	9.53	...	3.88	38.88	40.40	1.31	0.57	0.27
do.	9.24	...	3.74	37.65	48.24	1.13	0.57	0.47
do.	8.52	...	2.09	37.79	50.27	1.33	0.49	0.41
Bangalore	9.40	6.48	8.91	35.13	44.42	2.14	0.51	0.57
do.	12.08	6.78	10.05	41.14	53.13	2.38	...	...
do.	5.91	3.53	3.42	27.23	43.10	1.06	...	...
do.	8.55	4.96	7.75	32·36	49.61	1.73	...	...
do.	8.06	4.85	4.63	38.66	47.49	1.16	0.35	0.48
Bihar	7.58	4.96	2.85	30.91	57.48	1.18	0.59	0.42
do.	5.68	3.41	3.49	30.89	58.49	1.45	0.62	0.33
Punjab	8.96	4.78	5.21	38.87	45.59	1.37	0.69	0.41
do.	6.37	3.40	3.76	35.13	53.34	1.40	0.59	0.32
do.	7.11	3.50	3.87	33.68	53.78	1.56	0.63	0.25
Bangalore	11.76	10.95	25.81	35.21	39.94	3.08	...	...

The samples of *doob* (*Cynodon dactylon*) were taken from a lawn which received periodic irrigation. The protein, calcium and phosphoric acid all remain conspicuously high (see Table IX), although the P_2O_5 tends to fall off towards the hot summer months and at the end of the period when cold ensues. A sample from Hissar has a protein content of 20 to 22 per cent with satisfactory CaO and P_2O_5, whereas a sample of mature grass from the *bir* at Karnal has a low figure for protein. CaO and P_2O_5.

Palwan (*Andropogon pertusus*) is inferior to *anjan* and *doob*; *chhimbar* (*Eleusine flagellifera*) has a high protein figure, and CaO and P_2O_5 remain practically constant. The data for grasses under controlled and natural conditions are taken to indicate that, when left to mature naturally as is usually the case, there is a fall in protein and P_2O_5 with simultaneous reduction in digestibility, while the figure for CaO tends to remain more steady.

Seasonal Variations In Grasses

In addition to the seasonal variations already noted above, studies have been made on the effect of increasing maturity on the chemical composition of 19 indigenous and exotic grasses in the Animal Nutrition Division of the Indian Veterinary Research Institute, Izatnagar.

Apluda mutica
Bothriochloa intermedia
B. pertusa
Cenchrus ciliaris
Chrysopogon montanus
Cynodon dactylon
C. plectostachyon
Dichanthium annulatum
Digitaria pentzii
D. seriata
D. swasilandensis
Eremopogon faveolatus
Eulaliopsis binata
Heteropogon contortus
Iseilema laxum
Panicum maximum
P. phregmatoides
Setaria, Dutoitskrall strain
Sporobolus arabicus

The earliest cuts (in the month of August during the monsoon) of all the grasses are characterized by relatively high protein and low fibre percentages. The next two cuts in September and October show a marked fall in protein and a progressive increase in crude fibre. In most cases, the protein content falls to a very low level with increasing maturity although the following species retain their

protein content quite satisfactorily : *Apluda mutica, Bothriochloa pertusa, Dichanthium annulatum, Sporobolus arabicus* and *Chrysopogon montanus.* The percentages of protein, calcium, potassium, phosphorus and chlorine seem to vary in the same direction ; in a few exotic species, calcium and phosphorus show opposite variations. Sodium and magnesium show only slight variations, the magnitude varying in different grasses. Each species has a tendency to have its own characteristic chemical make-up Perennial grasses invariably show a considerable excess of calcium over phosphorus ; in exotic grasses, phosphorus tends to exceed the calcium Some grasses show a poor digestibility co-efficient of protein. In the case of *Sporobolus arabicus,* this is due to the presence of a large quantity of sulphur. The digestibility co-efficient of the protein improves if the sulphur is removed by water treatment.

Patel, Patel and Patel (1950) have studied the influence of different stages of cutting and stage of growth on the forage value of Napier and Guinea grasses grown on alluvial loamy soils at Anand without manuring or irrigation. Yields and percentage leafiness are given in Tables XXIV to XXVII. On the whole, Guinea grass is best in terms of crude protein content ; it gives the best forage value when first harvested between the pre-shooting and boot-leaf stages and subsequently when cut at monthly intervals (Table X).

TABLE X

Crude protein content in Guinea and Napier grasses

Particulars		Average crude protein percentage on dry basis	
		Guinea	Napier
Cut at 30 days		7·25	6·38
Cut at 50 days		6·45	6·21
Cut at 60 days		4·88	4·42
Stage of cut :			
Leafy	(a) Leaves	7·81	7·01
	(b) Stems	3·93	3·81
Boot-leaf	(a) Leaves	5·54	3·60
	(b) Stems	3·72	1·75
Inflorescent	(a) Leaves	4·90	3·40
	(b) Stems	2·19	1·30
Post-bloom	(a) Leaves	4·34	2·81
	(b) Stems	1·17	1·22
Mature	(a) Leaves	3·23	1.89
	(b) Stems	0·94	1·00

Trace Elements

Analytical studies have been made at the Animal Nutrition Laboratory, Indian Veterinary Research Institute, Izatnagar, on the content in grasses of trace elements such as cobalt, copper and magnesium in relation to certain pathological symptoms in livestock.

Table XVII gives the results of analyses of grasses and legumes made at the Indian Agricultural Research Institute for cobalt and copper content. All grasses have adequate amounts in the young stage, but some become marginal or deficient at the flowering stage. With increasing age there is a gradual fall in cobalt and copper content. Napier grass, green maize, cowpeas and berseem are good in this respect. The uptake of cobalt and copper by berseem under different fertilizer treatments is discussed in Chapter XIII.

Shah and Patel (1948) found that feeding iodine in the form of potassium iodide to buffaloes at the rate of 100 mgm. per day increases milk yield considerably, but the fat percentage is reduced during the early stages of lactation. (See also Chapter XVIII).

Feeds And Quality Of Dairy Products

Patel and Ray (1948, 1949) have studied the effect of feeding cottonseed to milch animals from the following aspects :

Effect on production of milk and butter-fat in buffalo of (a) equivalent replacement of dairy mixture by cottonseed, and (b) exclusion of green fodder in a cottonseed diet.

The quality of *ghee* from buffalo fed on cottonseed in combination with dry or green fodder.

The effect of large ingestion of oil through cottonseed on the secretion and stability of carotene and vitamin A in the butter-fat of the cow.

Quality Of Straws

The straws of the three main cereals, wheat (*bhusa*), millet and rice, and the dry stems, stover or *kadbi* of *juar* are the predominant dry roughages of Indian village cattle. Sen (1952) quotes results of analyses (Table XI).

PLATE I

Hay conserved on rooftops in the Himalayas, northern Uttar Pradesh

Photo : R. O. Whyte

TABLE XI

Composition of roughages

Roughage	Crude protein	CaO	P_2O_5
Barley ...	2·21	0·46	0·19
Juar ...	4·91	—	—
Millet ...	5·39	—	—
Ragi ...	3·67	1·11	0·16
Rice ...	2·40 to 5·69	0·19 to 0·71	0·12 to 0·25
Wheat ...	2·39 to 3·28	0·42	0·15

Rice straw, the chief fodder available in Crop Zone A, may have up to 1.5 per cent of soluble oxalates; calcium assimilation is interfered with and a rotation based on this roughage is particularly poor in available calcium. This defect may be corrected by treatment of the straw before feeding.

Lander and Dharmani (1931) investigated rice straw as a fodder for the poor and neglected livestock of the Kangra Valley in the Punjab, a district covering some 10,000 square miles from the plains of the Bari and Jullundur Doabs over the Himalaya to the borders of Tibet. The average weight of the indigenous breed of cattle is only 500 lb., but this is essential to plough the minute and narrow fields on the hillsides. The stock are, however, sturdy and would be admirably adapted to their environment if malnutrition did not reduce their agricultural value and render them susceptible to disease. The same remarks apply to the people also. The important feature of the study is that Kangra rice straw, on which the cattle chiefly exist, is deficient in protein (2.4 per cent), calcium (0.4 per cent) and phosphoric acid (0.25 per cent). The straw does not provide a maintenance ration at Lyallpur for three-year-old Sahiwal heifers weighing from 360 to 450 lb.; the digestibility of the protein is negative, indicating that what protein is available cannot be utilized properly (or that the animals draw on their body protein to digest it).

Important work on the nutritive value of grasses and fodders was done in undivided Bengal in the 15 years up to partition in 1947; for example, the

approved programme for the year 1946-47 covered the following items :

- animal nutrition survey,
- digestibility and nutritive value of important edible aquatic grasses including *Hemarthria compressa*,
- digestibility and nutritive value of local grasses and their by-products, and
- feeding value of rice straw in relation to the growth of the cattle.

Results of the work on rice straw have been given in the following papers : Chatterjee and Hye (1938), Carbery and Chatterjee (1938), and Chatterjee and Sarkar (1947).

In the 1946-47 summary of the Annual Report of the Physiological Chemist, Animal Nutrition Section, Bengal, an experiment on the feeding of paddy straw to mature bullocks is reported. Attempts were made to keep the four groups into which these animals were divided as similar as possible rather than the animals within the groups being similar. The rations are given in Tables XII, XIII and XIV.

TABLE XII

Combinations of paddy straw with mustard cake

(Rations per 1,000 lb. body weight)

Group	Paddy straw	Mustard cake lb.	Green feed (roadside grass) lb.	Salt oz.
A	(Untreated) *ad lib* ...	1½	2	*Nil*
B	(Untreated) *ad lib* ...	1½	2	1
C	(Water treated) *ad lib* ...	1½	2	*Nil*
D	(Water treated) *ad lib* ...	1½	2	1

Table XIII

Combinations of paddy straw with rice kura *(bran)*

(Rations per 1,000 lb. body weight)

Group	Paddy straw	Rice *kura* lb.	Green feed (roadside grass) lb.	Salt oz.
A	(Untreated) *ad lib* ...	3½	2	*Nil*
B	(Untreated) *ad lib* ...	3½	2	1
C	(Water treated) *ad lib* ...	3½	2	*Nil*
D	(Water treated) *ad lib* ...	3½	2	1

Table XIV

Combinations of paddy straw with mustard cake and rice kura

(Rations per 1,000 lb. body weight)

Group	Paddy straw	Mustard cake lb.	Rice *kura* lb.	Green feed (roadside grass) lb.	Salt oz.
A	(Untreated) *ad lib* ...	¾	1¾	2	*Nil*
B	(Untreated) *ad lib* ...	¾	1¾	2	1
C	(Water treated) *ad lib* ...	¾	1¾	2	*Nil*
D	(Water treated) *ad lib* ...	¾	1¾	2	1

Analyses show that :

(i) in the experiment with the mustard cake combination, the interaction is significant only in the case of potash metabolism,

(ii) in the experiment with the rice *kura* combination, the interaction is significant only in the case of chloride metabolism, and

(iii) there is no significant interaction with the mustard cake and rice *kura* combination.

The I. C. A. R. hopes to arrange with the Government of Pakistan for the officer responsible for this work during most of the period to visit Dacca, East Pakistan, the centre at which the work was done. It is then hoped to summarize the results obtained on this and other aspects of the research at Dacca in a form suitable for publication. It was found, for example, that considerable differences in digestibility of rice-straw are reported by investigators working in different parts of India ; digestibility is further markedly influenced by variety, as between a transplanted winter variety, a broadcast autumn variety and a transplanted spring variety. The digestibility of proteins in the straw of these three types was 10, 23 and 30 per cent respectively.

Investigations on the utilization of paddy straw as a roughage have also been in progress for some time at the Indian Veterinary Research Institute, Izatnagar, Bangalore (Mysore), Lyallpur (West Pakistan), and Bharari, Jhansi (U. P). Since paddy straw is very widely used in India as roughage and as conflicting opinions with regard to its nutritive value existed between different workers, the Advisory Board of the Indian Council of Agricultural Research held in October, 1949, requested Dr N. D. Kehar to review the work already done on sodium / potassium metabolism following the feeding of paddy straw. This review, which not only contains available information with regard to sodium/potassium metabolism, but also throws light on the problem of paddy straw feeding from a broad view-point, was considered by a sub-committee of the Animal Nutrition Committee of the Indian Council of Agricultural Research in November, 1950, consisting of Dr K. C. Sen, Dr N. D. Kehar, Dr Lal Chand Dharmani, Dr S. K. Talapatra and S. P. Srivastava.

This sub-committee recommended "that as paddy straw was a very widely used roughage in India and as views have been expressed regarding some disadvantages in feeding it, further work on a regional basis should be carried out in

as many centres as possible." This Committee also felt that "feeding work with paddy straw should be carried out in all the States where paddy straw formed an important item of cattle-feed, but basic work especially, which required highly skilled technical staff and equipment, might be concentrated only in a smaller number of stations. The Committee requested Dr Kehar to prepare a scheme. The work of the different units would be co-ordinated by the Animal Nutrition Section at Izatnagar, which should have a central unit for this purpose."

These recommendations were approved by the Animal Nutrition Committee and the Scientific Advisory Board of the Council in November, 1950 and the Officer-in-charge, Animal Nutrition Section, Izatnagar, was requested to make proposals, in consultation with other members of the sub-committee. Further work on the nutritive value of paddy straw is to develop under the following heads :

(a) Work in States where paddy straw is an important item of cattle feed. These will be called the 'Field Units.'

(b) Basic work to be carried out with skilled technical staff at a few 'Regional Stations.'

(c) 'Central Unit' at Izatnagar to work on fundamental aspects and to co-ordinate the work of the various Field Units and Regional Stations.

Field Units. The work in these units will consist of examining the value of paddy straw compared with either wheat or *kadbi*. Experimental animals are to consist of growing and lactating animals and the effect of different roughages on the production rate will be studied. The value of paddy straw processed by various methods will also be examined. From time to time, various supplementary feeding trials as found suitable at (b) or (c) will be made on a large scale in these units, in *goshalas*, *pinjrapoles* and dairy farms. The work may be carried out in the following States : Jammu and Kashmir, Uttar Pradesh, Bihar, Bengal, Assam, Orissa Madras, Hyderabad (Dn) and Punjab.

Regional Stations. The number of Regional Stations may be limited to five—Mathura (U. P.), Gauhati (Assam), Bangalore in the South, Anand, and Ludhiana. The metabolic behaviour of animals receiving paddy straw either alone or in combination with different supplements will be studied.

The Central Unit. Further studies on the injurious substances present in

paddy straw will be undertaken at the Central Unit at Izatnagar. Methods of improving paddy straw through ensilage, supplementary feeding with other roughages, concentrates and minerals, etc. will also be studied.

Regional Research Scheme

Methods of livestock production and management vary widely in different parts of India, due to variability of rainfall, availability of feeding stuffs, types of indigenous grasses, possibility of fodder production, fodder conservation, etc. Workers in animal nutrition have long realized that the problems of stock feeding could be solved only by considerably enlarging the available research and extension activities. The Indian Council of Agricultural Research has, therefore, agreed to the establishment of centres at which important regional problems could be investigated and from which the information gathered could be easily disseminated.

Regional Centres have been set up at Anand, Bombay State (established in 1952), Bangalore (Mysore) and in West Bengal, in 1954. The work for the first four years and the order of priority of the various projects are as agreed by the Animal Husbandry Wing (Hyderabad, 1945) and accepted by the Advisory Board of the Indian Council of Agricultural Research in the same year.

1st Year :

Animal nutrition survey in two representative areas :

(*a*) Fodder available according to season.

(*b*) Analysis of monthly cuts to indicate best system of grazing and cutting.

(*c*) Analysis of common fodders and grains available in different seasons.

(*d*) Comparison of fodder intake with physiological requirements.

(*e*) Clinical evidence of deficiency diseases.

(*f*) The most suitable methods of making silage in the different regions.

Second to fourth year :

It is expected that sufficient information would be available at the end of the first year on the chemical composition of the fodders and concentrates of the

regions. The work might then be extended to cover :

(a) Digestibility and nutritive value of fresh and ensiled grass and fodder crops.

(b) Digestibility and nutritive value of local grains and oilcakes.

(c) The economics of feeding livestock.

Current I. C. A. R. Research Projects

(*a*) Nutritive value of certain indigenous grasses and tree leaf fodder.

These studies are being conducted at the Indian Veterinary Research Institute, Izatnagar. In the earliest stages of growth, tree leaves are relatively high in crude protein and low in fibre ; with increasing maturity, there is a fall in protein content and an increase in fibre. Tree leaves are very rich in calcium which increases as the leaves mature. The phosphorus content, which is almost equal to that of grasses, is highest in the early stages and decreases with maturity. Although most tree leaves have a high protein content, the digestibility co-efficient is generally poor ; the protein of those tree leaves which contain large amounts of tannic acid is poorly absorbed. Some tree leaves constitute a maintenance ration in themselves, others can contribute only partially.

(*b*) Potentialities of Indian village cattle for increased milk production through better feeding and management.

(*c*) Utilization of waste products as feed for cattle in Orissa.

(*d*) Feeding of balanced rations to village cattle in Orissa.

(*e*) Factors affecting the nutritive value of paddy straw.

(*f*) Value of urea in feeding Indian cattle.

Conclusion

We have presented in Chapters III and IV a statement of the core of the Indian problem, the great numbers and poor quality of the livestock which have to be fed, and the great deficiencies in quantity and quality of the grazing, fodders and feeds available to feed them. In later Chapters we will discuss some of the methods which have been suggested to meet the demand, but one cannot help feeling baffled by the magnitude of the task in relation to the limited and already over-taxed resources. The grasslands of India are capable of providing good grazing, if the management is greatly improved ; but this inevitably demands a reduction in the number of beasts per acre and in the annual duration of their grazing. There are already sixteen bovines per acre on the existing fodder

acreage, disregarding all other classes of livestock. Can the fodder acreage possibly be increased sufficiently to take some of the strain off the overgrazed grasslands and permit them to provide better grazing while at the same time conserving soil and water ?

Practically all possible sources of fodder are at present being utilized, and yet straw remains the most important source of nutriment. Kehar (1953) has repeatedly stressed the great untapped resources which are virtually being allowed to go to waste, e.g. mango seed kernel, *jaman* seed, tamarind seed, fish meal and residues from slaughter houses, seeds of *Cassia tora* and the fruits of the rain tree could, according to Kehar, be used to supply valuable concentrates. Sugarcane tops, *mahua* flowers, *bajra* husk and *juar* husk, *kantiara* and other by-products possess substantial nutritive value. Kehar hopes that it may be possible to impress cultivators with the value of these substances as cattle feeds ; it is estimated that one could obtain about 11 million tons of concentrate feeds and 300 million tons of roughage on an all-India basis, providing 4·8 million tons of digestible crude protein and 26·5 million tons of starch equivalent. It may be that the total amount which might be obtained in any particular village, if interpreted in pound or tons per acre per annum for all the cultivated land of a village, would not be very great, possibly much less than one or two acres of high-producing fodder crops. Again, with livestock of the present quality, are villagers going to make any special effort to collect or purchase unusual fodders which do not come to hand easily, like *bhusa* or *kadbi* ?

In the present situation, the objective must necessarily be to obtain maximum bulk from fodders, feeds and grazing, and at the same time to try and do something about raising their quality. Well-designed rations are at the moment purely of academic interest. For those who wish to study this aspect, reference should be made to Sen (1952) ; he discusses the problem with reference to the particular types of Indian cattle, and compares their needs with those of Western breeds of cattle for which Morrison, Kellner and others have produced feeding standards. Our only reference to the feeding quality of cattle rations is in Table XXXV in which Shacklady (1953) has presented all the ingredients of a grazing and fodder calendar at Bharari, Jhansi, in terms of digestible protein and starch equivalent. Such an exercise will be relevant after we have begun to meet the essential and basic needs of Indian livestock.

TABLE XV

Analysis of anjan (*Cenchrus ciliaris*)

(Data supplied by the Physiological Chemist, Bangalore)
(Lander, 1942)

Description	Per cent on dry crop							
	Ash	Protein	Insoluble residue	Calcium (CaO)	Magnesium (MgO)	Sodium (Na_2O)	Potassium (K_2O)	Phosphoric acid (P_2O_5)
Pusa, Bihar, 1932-33								
Young	21·21	10·76	5·63	1·27	0·54	0·59	8·94	0·54
Prime	12·50	9·18	3·96	0·63	0·38	1·17	3·99	0·42
Ripe	12·63	6·28	6·10	0·77	0·39	1·42	2·56	0·39
Pusa, Bihar, 1933-34								
Young	12·74	5·14	2·78	0·64	0·48	1·76	3·60	0·57
Prime	13·94	4·73	9·41	0·94	0·37	0·56	1·02	0·45
Poona, Bombay, 1932-33								
Young	4·85	14·21	0·22	0·50	0·61	1·13	0·66	0.23
Prime	23·73	10·46	18·48	0·60	0·72	1·02	0·61	0·21
Sabour, 1932-33								
Young	13·95	5·82	8·62	0·49	0·17	1·28	1·93	0·77
Prime	12·84	9·23	5·93	0·55	0·32	1·19	3·31	0·58
Ripe	14·17	6·18	7·88	0·56	0·28	1·11	2·61	0·82
Sabour, 1933-34								
Young	20·28	7·88	13·51	0·59	0·34	0·92	2·22	0·68
Prime	14·53	9·58	6·25	0·74	0·43	0·89	4·20	0·55
Ripe	14·34	4·16	9·16	0·56	0·31	0·77	0·88	0·87
Bangalore, 1932-33								
Young	13·49	14·37	4·29	0·43	0·37	1·35	3·89	0·67
Prime	11·72	11·91	3·95	0·44	0·43	1·58	3·05	0·50
Ripe	9·22	7·06	4·03	0·48	0·45	1·17	1·62	0·31

TABLE XV—(*contd.*)

Analysis of anjan (*Cenchrus ciliaris*)

(Data supplied by the Physiological Chemist, Bangalore) (Lander, 1942)

Description	Per cent on dry crop							
	Ash	Protein	Insoluble residue	Calcium (CaO)	Magnesium (MgO)	Sodium (Na_2O)	Potassium (K_2O)	Phosphoric acid (P_2O_5)
				Bangalore, 1933-34				
Young	14·15	10·45	4·88	0·38	0·33	1·31	4·38	0·63
Prime	11·41	8·02	5·97	0·53	0·34	0·81	1·92	0·44
Ripe	11.29	7·44	6·62	0·37	0·34	0·60	1·72	0·47
				Ajjampur (Mysore), 1932-33				
Hay (young)	12·47	7·77	6·11	0·84	0·41	0·067	2·90	0·44
Hay (prime)	11·60	5·44	5·96	0·60	0·39	0·18	2·18	0·44
Hay(ripe)	8·48	3·21	4·27	0·51	0·49	0·13	0·82	0·15
				Aurangabad, 1933-34				
Hay (young)	14·48	4·16	12·25	0·57	0·34	0·23	0·67	0·19
Hay (prime)	15·40	2·58	12·93	0·51	0·28	0·29	0·59	0·13
Hay (ripe)	15·58	1·66	13·62	0·55	0·26	0·39	0·23	0·049
				Meerut, 1931-32				
Hay (young)	10·39	4·11	5·94	0·38	0·22	0·18	2·00	0·53
Hay (prime)	10·71	3·75	6·79	0·39	0·26	0·27	1·74	0·42
				Jubbulpore, 1931-32				
Hay (young)	10·77	4·15	6·51	0·68	0·34	0·23	1·55	0·32
Hay (prime)	8·63	3·24	5·56	0·48	0·33	0·36	1·12	0·15
Hay (ripe)	11·96	2·58	9·51	0·50	0·26	0·028	0·90	0·28
				Bellary (Average)				
Hay (ripe)	12·69	2·98	10·44	0·59	0·45	0·25	0·50	0·12

TABLE XVI

Variation in minerals in anjan *over* $3\frac{1}{2}$ *months' growth* (*Lander, 1942*)

(Sown on 27th May 1933 at Lyallpur)

Date of sampling	Description	Per cent on dry crop														Remarks Soil (Type)
		Ash	Fat	Crude fibre	Protein	Soluble carbohydrates	Insoluble residue	Iron (Fe_2O_2)	Aluminium (Al_2O_2)	Calcium CaO	Magnesium (MgO)	Sodium (Na_2O)	Potassium(K_2O)	Phosphoric acid (P_2O_5)	Sulphates (SO_4)	
								1933								
4 September	1st cut (just flowering)...	17·64	1·87	25·30	12·02	43·17	7·04	0·25	0·27	0·72	0·34	1·58	4·53	0·79	0·61	Loam soil
4 October	Pre-milk stage ...	16·80	2·02	25·76	11·98	43·44	8·19	0·12	0·55	0·66	0·40	1·00	3·92	1·05	0·68	do.
4 November	Milk stage ...	17·97	2·10	25·90	10·87	43·16	8·10	0·20	0·61	0·70	0·30	1·04	4·26	0·83	0·68	do.
4 December	Ripe stage ...	16·99	2·03	28·68	11·52	40·78	7·91	0·20	0·51	0·59	0·36	0·98	4·04	0·86	0·61	do.
8 December	Dead ripe stage (some... seeds already shed)	16·68	1·78	30·01	9·09	44·44	5·72	0·11	0·50	0·56	0·32	1·08	...	0·72	0·78	do.
								1934								
13 August	1st cut (just flowering)...	19·89	1·99	26·74	11·30	40·08	9·62	24	0·29	0·72	0·40	1·60	3·90	0·78	0·76	do.
12 September	Pre-milk stage ...	18·06	1·60	30·98	10·36	39·00	7·34	20	0·39	0·69	0·30	1·72	4·08	0·76	0·61	do.
15 October	Milk stage ...	17·64	1·70	31·42	9·38	39·86	8·64	20	0·45	0·64	0·32	1·00	2·96	0·67	0·69	do.
12 November	Ripe stage ...	18·23	1·64	29·51	10·08	40·54	9·24	15	0·51	0·60	0·43	1·01	0·67	0·67	0·74	do.
21 December	Dead ripe stage ...	17·76	1·60	30·16	9·69	40·79	8·18	17	0·41	0·62	0·32	1·91	2.90	0·60	0.61	do.

TABLE XVII

Cobalt and copper content of grasses and other forages at different stages of growth (Indian Agricultural Research Institute, New Delhi)

Species	Cobalt p.p.m. D.M.				Copper p.p.m. D.M.			
	Young	Preflowering.	Flowering	Classification according to Russell (1944.)	Young	Preflowering	Flowering	Classification according to Russell (1944)
Grasses :								
Dichanthium annulatum	0·30	0·10	0·04	D	10·2	9·0	7·0	S
Amphilophis odorata ..	0·33	0·12	0·09	S	8·3	4·4	4·4	D
Iseilema laxum ...	0·55	0·12	0·12	S	11·7	8·2	4·4	D
Themeda tremula ...	0·20	0·07	...	...	15·3	4·8	...	...
Amphilophis glabra ...	0·22	0·13	0·17	S	9·1	9·0	8·6	S
Pennisetum orientale ...	0·33	0·12	0·05	D	9·8	7·5	7·4	S
Panicum repens ...	0·36	0·06	0·05	D	10·1	9·7	6·2	S
Chrysopogon montanus...	0·35	0·09	0·07	M	10·5	4·5	4·1	D
Sehima nervosum ...	0·38	0·09	0·07	M	8·8	5·4	4·5	D
Heteropogon contortus...	0·24	0·12	0·12	S	10·2	7·2	6·0	M
Cynodon dactylon (*Dub* grass) ...	0·10	...	...	...	9·2	...	...	...
Themeda anathera ...	...	...	0·10		...	...	4·0	D
Cenchrus setigerus ...	...	...	0·11	S	...	...	7·1	S
Arundinella hispida (Syn. *Arundinella nepalensis*).	...	...	0·13	S	...	...	8·2	S
Mnesithea laevis ...	...	...	0·09	S	...	...	5·5	M
Digitaria sanguinalis (Syn. *Digitaria marginata*) ...	...	...	0·25		...	...	8·5	S
Forage crops :								
Napier grass (*Pennisetum purpureum*) ...			0·29				14·3	
Maize plants (*Zea mays*)			0·28				6·1	
Berseem (*Trifolium alexandrinum*) ...			1·06				10·48	
Cowpea (*Vigna sinensis*)			0·60				8·4	

S ... Sound M ... Marginal D ... Deficient

CHAPTER V

ECOLOGY OF VEGETATION

THE vast sub-continent of India and Pakistan lies entirely to the north of the Equator, between latitude 8° and 36° N. Being cut off from the rest of Asia by a great mountain wall, India and Pakistan should be regarded as a biological unit. India proper can be divided into three main parts, the mountain wall, the plains of Hindustan or plains of Northern India, and the plateau of peninsular India.

Geologically the structure of India is very simple, there being only two distinct units, (a) a very ancient stable massif of which the central portion forms the Deccan, together with the later rocks which cover much of its surface and especially its edges, and (b) the belt of fold mountains which warp around the ancient blocks and which may perhaps be regarded as owing their existence to compression against its resistant edge (Stamp, 1939).

Physiography And Climate

Although India is always thought of essentially as a tropical country, practically the whole of the Gangetic plain, for example, lies outside the tropics. The climate of the country as a whole is largely influenced by the physiography, and in particular by the following ranges and hills (Troup, 1926) :

(1) The Himalayan range, forming a great barrier to the north ;

(2) The Western Ghats, running parallel to and at no great distance from the west coast of the peninsula, together with the Nilgiri and other hills of Southern India ;

(3) The great complex of mountains flanking the Himalaya on the east and extending into the northern parts of Burma ; and

(4) The ranges extending southward from this complex.

The most important feature in the meteorology of India is the alternation of seasons known as the monsoon (Ramdas, 1953). Monsoons are seasonal winds,

the direction of which more or less reverses twice during the year. Lying largely within the tropics and with the great Asiatic continent to the north and the wide expanse of the Indian Ocean to the south, India furnishes the best large-scale example of a monsoon country. During the winter months, December to February, the general flow of surface air over the country is from north to south, north-westerly in the plains, northerly in the central parts and north-easterly in the south of the peninsula and the neighbouring seas. In this season, the air over the country is mainly of continental origin and hence of relatively low humidity, and the northern parts of the country get their very variable winter rainfall. In the months June to September, the general flow of wind is from the opposite direction from sea to land and the season is one of much humidity, cloud and rain. More than 75 per cent of the annual rainfall in the different parts of the country, excluding certain areas in the south of the peninsula and in Assam and Kashmir, is received during these months. The direction of winds in the major parts of the Arabian Sea and the Bay of Bengal being south-westerly, the season is named the south-west monsoon season. Between these two principal seasons are the transition seasons of the hot weather months, March to May, and the retreating monsoon months, October and November, during which the east coast in the south of peninsula gets practically all its rainfall, known as the 'Northeast Monsoon rains.'

Owing to the great size and position of India, and the diversities of relief, there are many striking contrasts of meteorological conditions in different parts of the country. In the north-west lies the great Thar desert with an average annual rainfall of less than 5 inches; in the north-east are the Khasi Hills with an average annual fall of 425 inches at Cherrapunji, Assam. Dras in Kashmir has recorded a minimum temperature of 41°F., while stations in west Rajasthan have several times registered a temperature of over 120°F. Hill stations in the Himalayas such as Simla may be shrouded in cloud for days together in August with humidities of 100 per cent, while in December they may be characterized by air of nearly zero humidity. The mean maximum temperature at Cochin does not go above 91°F. in any month nor the mean minimum below 71°F.; while at Jacobabad in Sindh, the mean maximum goes upto 111°F. in June and the mean minimum to 43°F., in January.

Figs. 2 to 11 show the normal rainfall and rainy days in the different seasons, and mean maximum temperature in May and mean minimum temperature in January.

Fig. 2

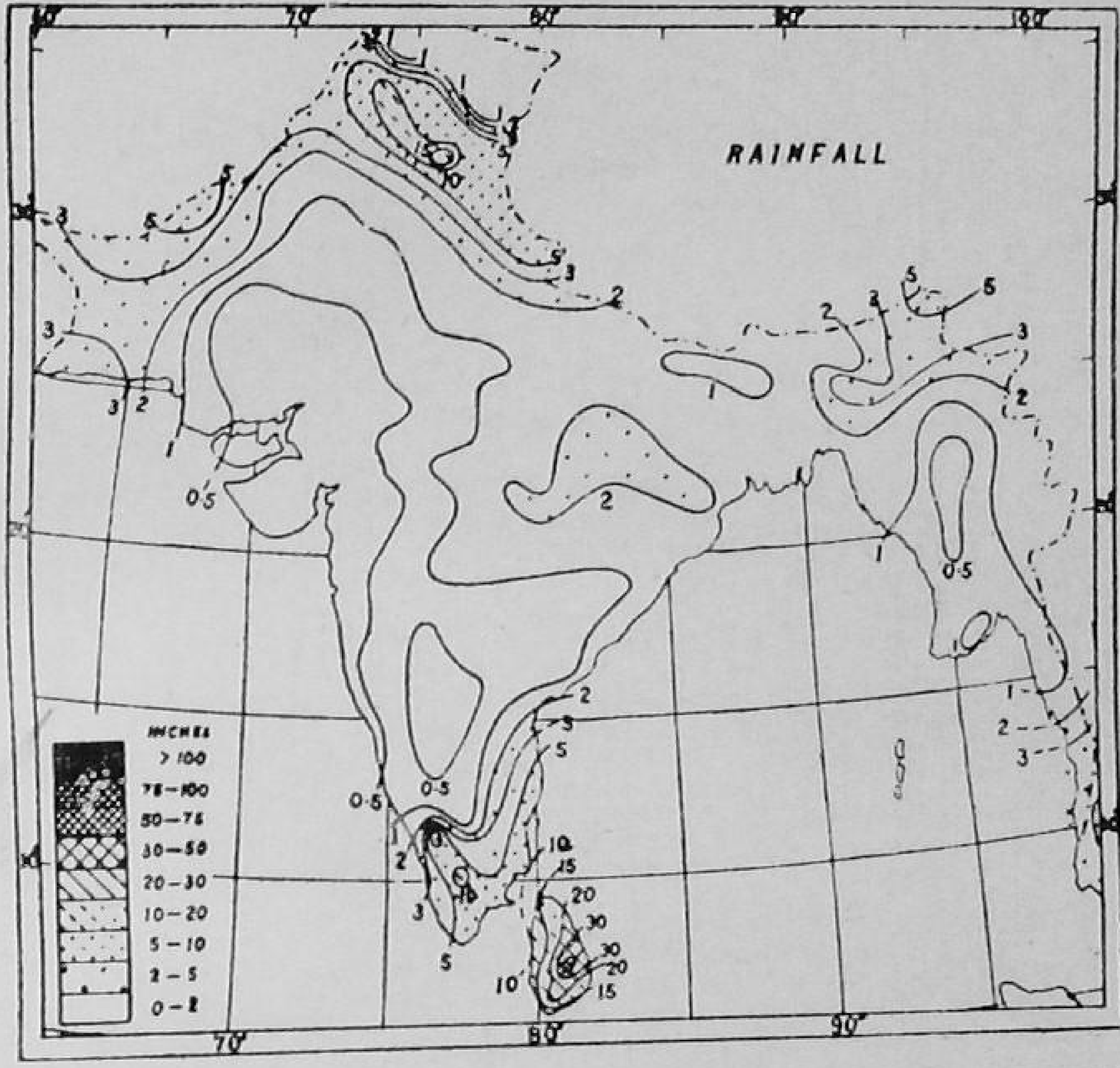
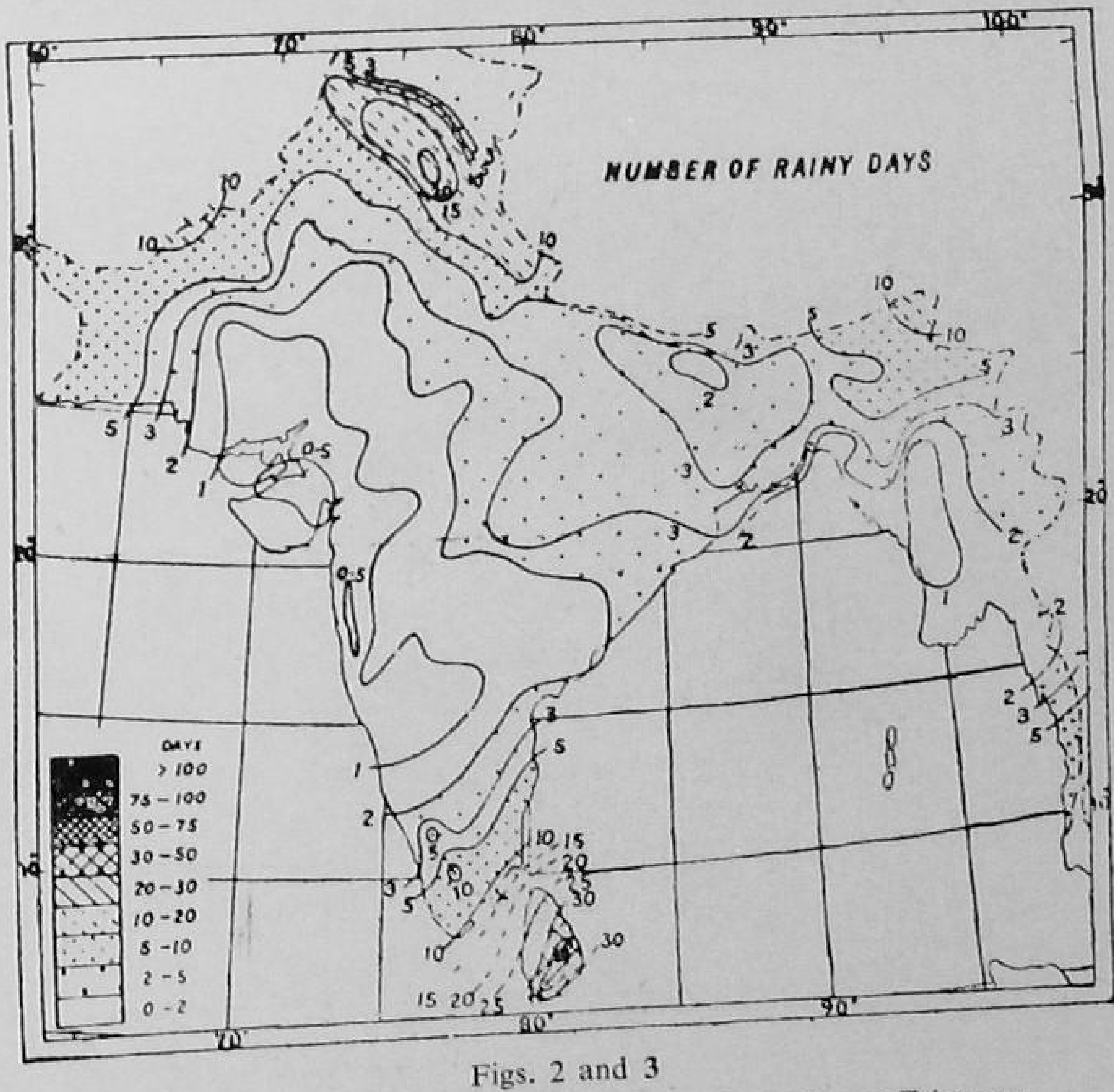


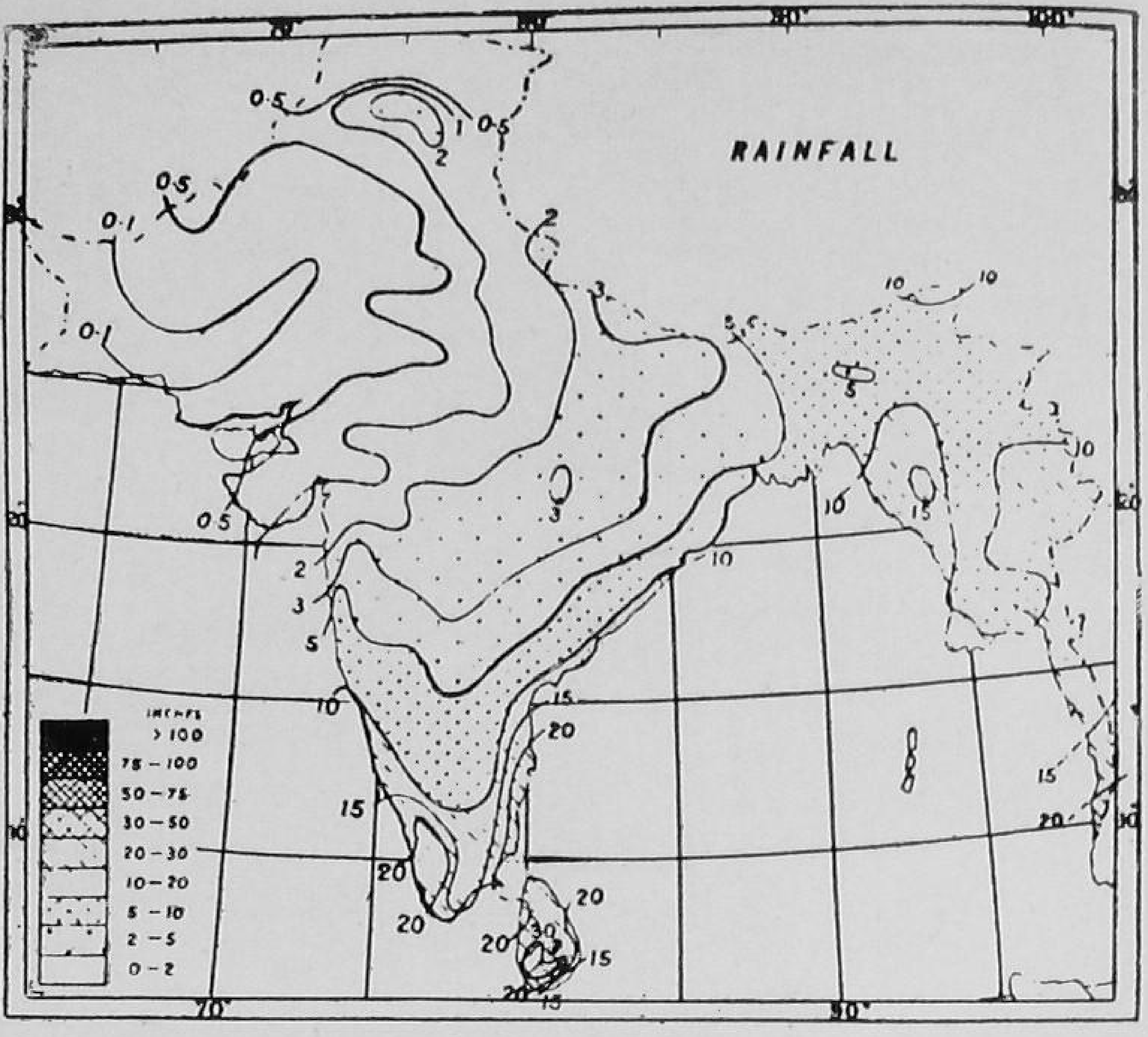
Fig. 3



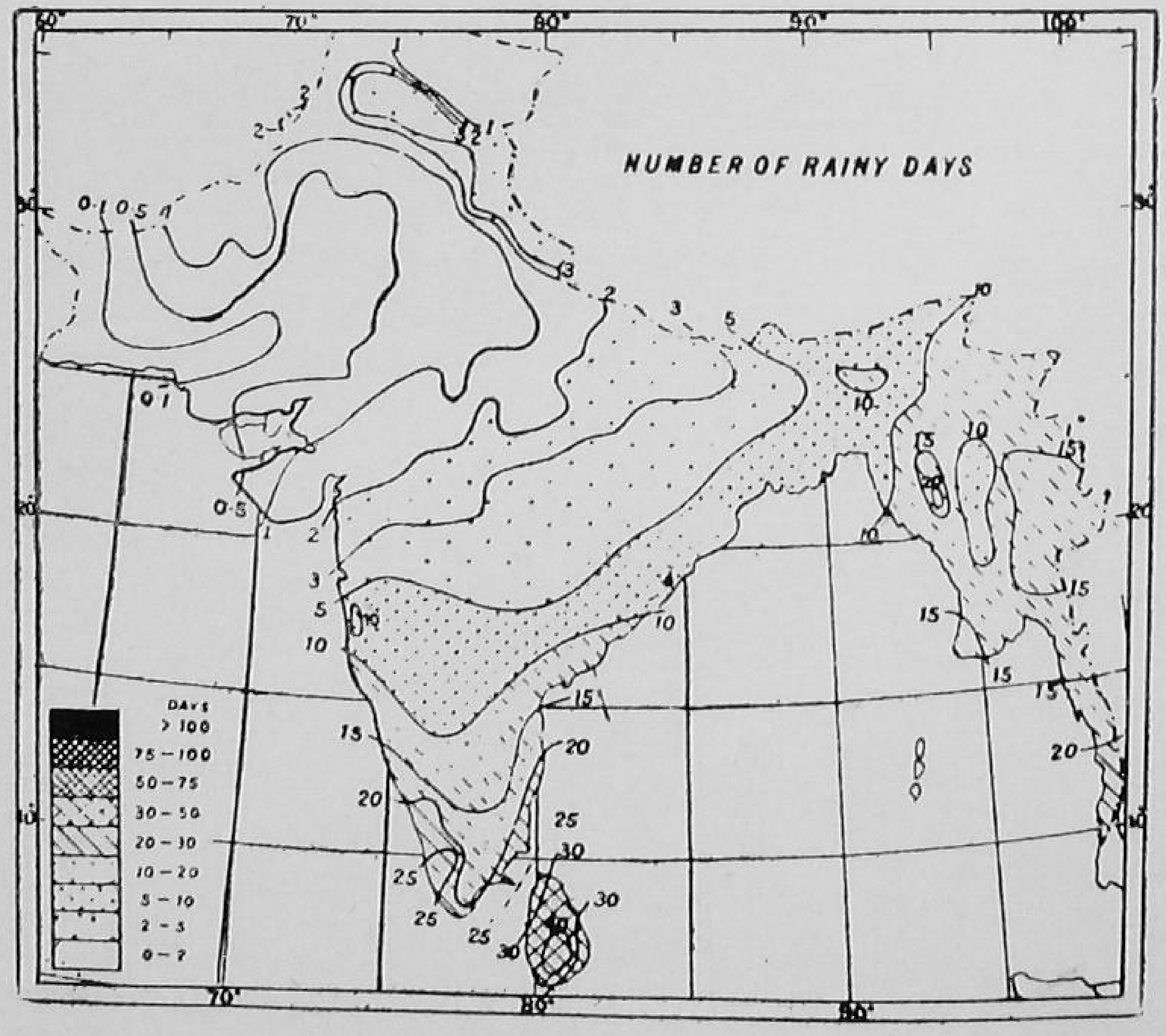
Figs. 2 and 3

Seasonal rainfall and number of rainy days, December to February.

Fig. 4



Fig, 5



Figs. **4** and 5

Seasonal rainfall and number of rainy days, October and November

Areas with the heaviest rainfall (as in Assam) are characterized by luxuriant forest vegetation, partly or entirely evergreen. On the leeward sides of mountain ranges such as the Western Ghats (rainfall up to 200 inches), the rain clouds deposit most of their moisture before descending into warm strata of air in the Deccan plateau ; the rainfall here is less than 30 inches, and the forest is of an open stunted type passing in the driest parts into open thorn scrub. Over the rest of India, the rainfall is between 30 to 75 inches and the forest characteristically deciduous.

The effect of temperature on vegetation is best demonstrated by the altitudinal zonation to be seen in the Himalayas. Frost has an effect on the distribution and to some extent on the habits of forest trees. Diurnal and annual ranges of temperature, greatest away from the coast, have an influence on the distribution of species.

Principles of Plant Ecology

The discussion which follows in this Chapter and in Chapter VI, and which provides the foundation for the understanding and management of natural grasslands in India, is based upon accepted principles of the ecology of plants in their natural associations. This is a broad subject of modern plant science which has been discussed in many text books, monographs and technical articles. Space does not permit a detailed consideration of the subject in this publication, particularly since its particular application to the forest and grassland vegetation of India will be made clear in the following sections.

The main need is to appreciate the place of natural and induced vegetation in the climate/soil/vegetation complex and more particularly in the present connection to understand the effects of the biotic factors like burning, cutting, grazing and shifting cultivation. These biotic factors in their various combinations and permutations and their varying degrees of intensity cause a deterioration of conditions in the habitat, particularly towards increasing desiccation, and so also a deterioration in the vegetative cover. Its economic value and capacity to protect the soil and conserve moisture are, therefore, diminished.

Ecological Status Of Grasslands

Grassland may be said to be the land on which gramineous species represent the dominant if not the exclusive vegetation. Not all that is called forest or

which comes under the Forest Administration is really forest ; many such areas are grasslands. When grasses no longer predominate and trees get the upper hand, we have woodland or forest.

There are hardly any artificial grasslands in India, certainly none in the forests, but the existing grasslands are not wholly natural either In an indirect way, they owe their existence to human activities. The consensus of opinion among ecologists is that, but for the lopping, shifting cultivation, burning and grazing practised through the ages in the forests, there would probably be no grasslands as such in India.

It has been inferred from the studies of the past climates and migrations of plant communities in certain parts of the world that, during long periods of greater humidity, a good part of the marginal grassland was deciduous forest and much of the grass/marginal desert was grassland. The opposite would have happened during prolonged periods of greater aridity (Weaver and Clements, 1938). In a grassland climax, exceptionally favourable conditions bring in the deciduous forest (post-climax) and exceptionally unfavourable conditions the desert (pre-climax) (Oosting 1948). As a climax formation, therefore, grassland is intermediate in status between forest or woodland on the one hand and desert on the other.

In India, however, while woodland and desert occur as climax formations, climax grassland, in the true sense, equivalent to steppe, range, pampa or savannah, appears to be absent. Bor (1942), for example, considers that the climate in India is either a forest climate or a desert climate. Champion (1935) also doubts the existence in India of any examples of climax grasslands, although grassland is common enough as an interim stage in the succession (seral stage) and sometimes may even be relatively very stable ('pre-climax') under the influence of repeated fire and grazing. The typical savannah type of grassland which is believed to occur as a climatic climax in other parts of the tropics and sub-tropics is apparently absent as such in India. The closed deciduous forest grades into thorn forest without an intermediate open park-like stage, and there is no steppe or range type of grassland climax between the woodland and the desert. Even the alpine grasslands have been subjected to such intensive summer grazing for centuries that we cannot venture to suggest what species might be represented in the truly climax stage there.

Plate II

A road in the Terai, Uttar Pradesh, showing the annual type of kans (*Saccharum spontaneum*) which is most plentiful in this area and flowers in September/October

Photo : D. Chatterjee

Fig. 6

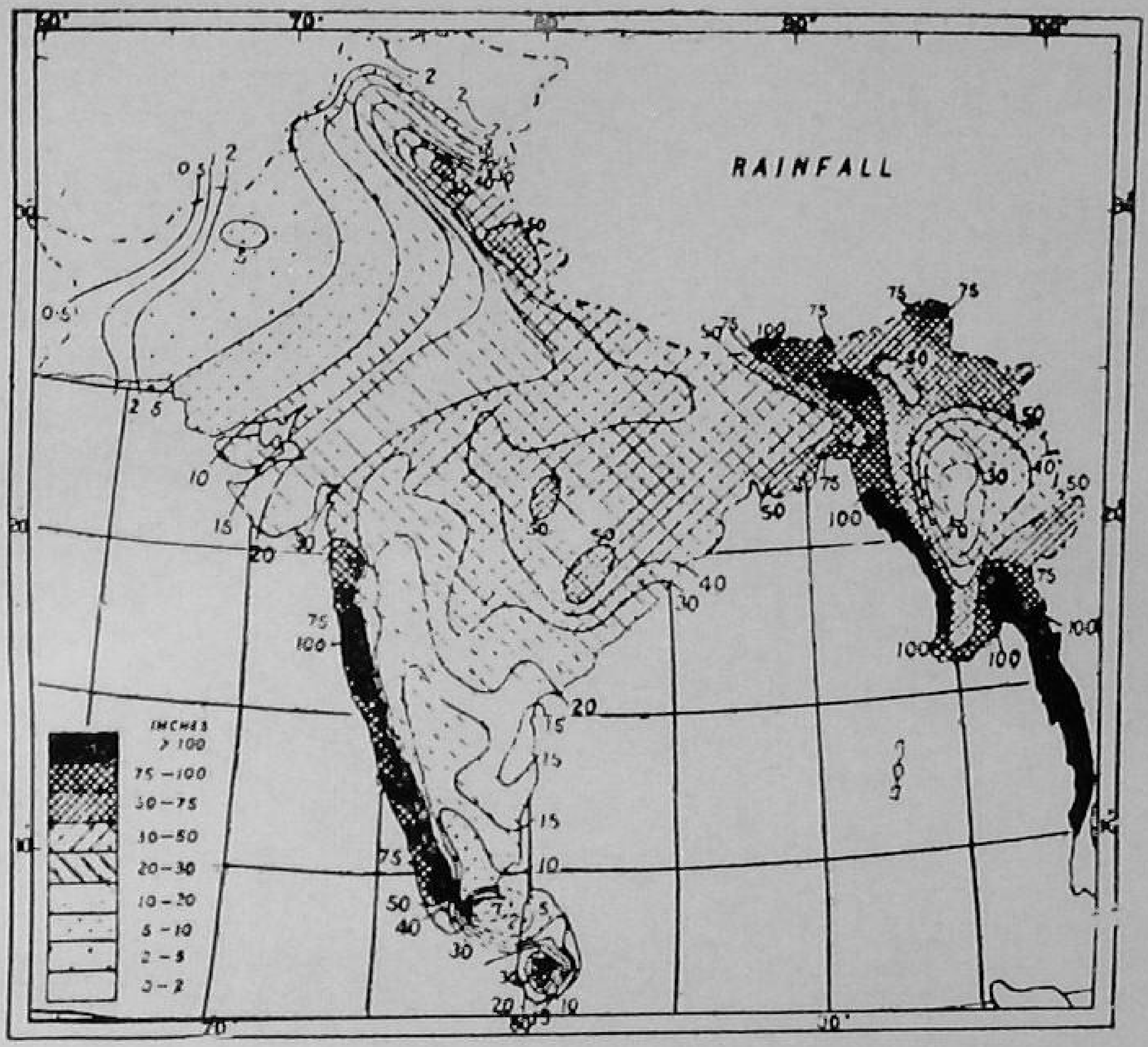
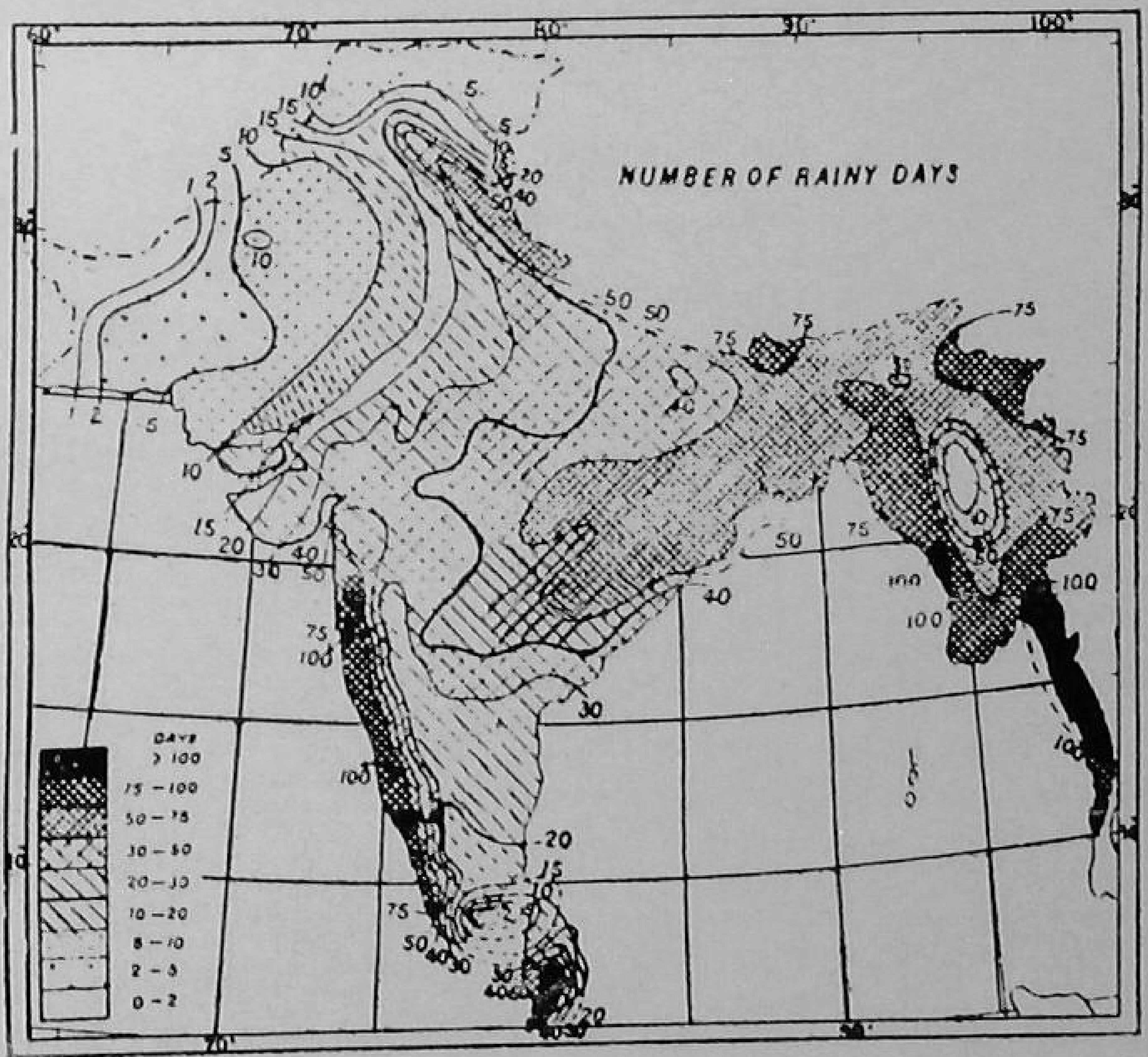


Fig. 7



Figs. 6 and 7

Seasonal rainfall and number of rainy days, June to September

Fig. 8

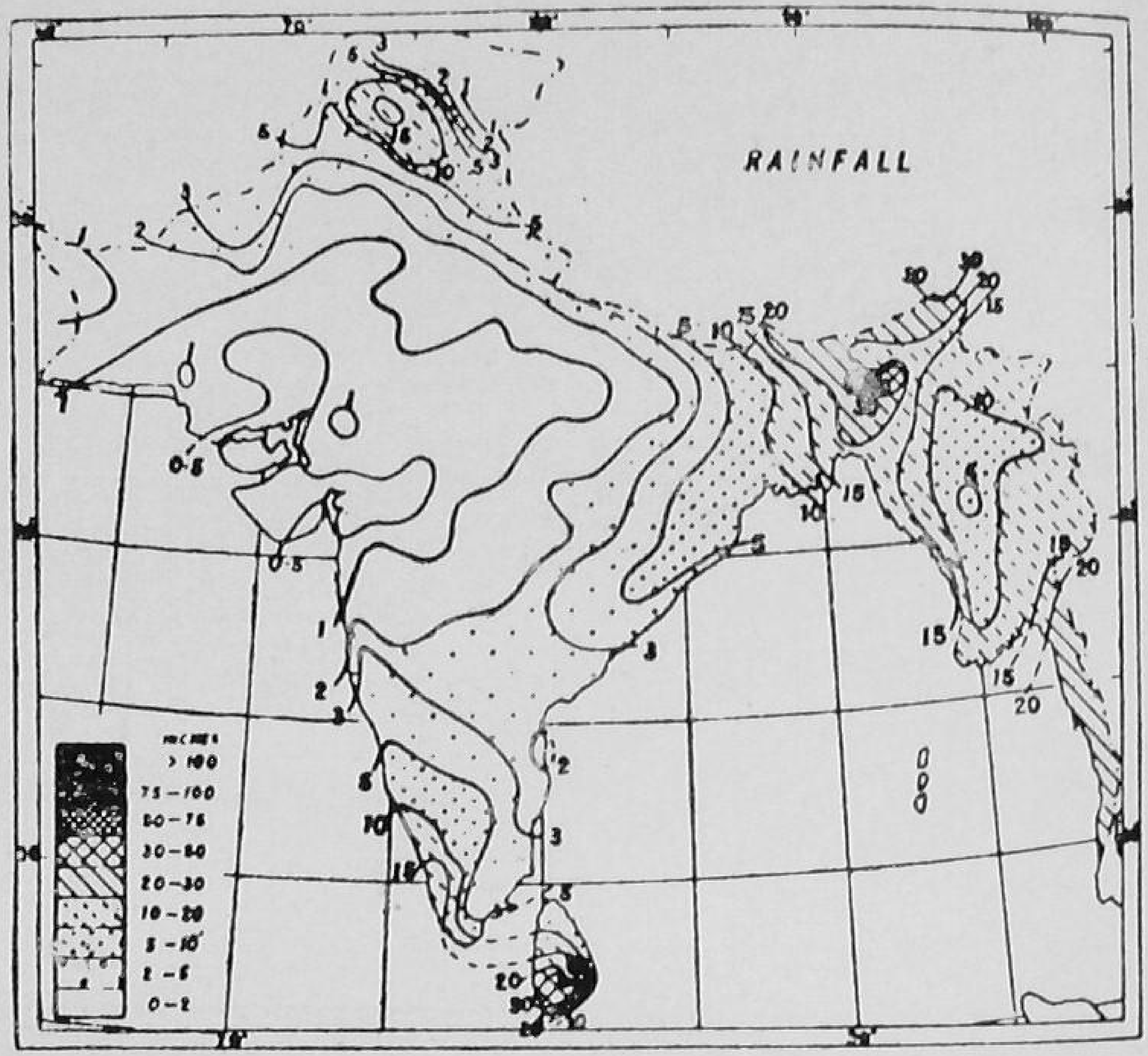
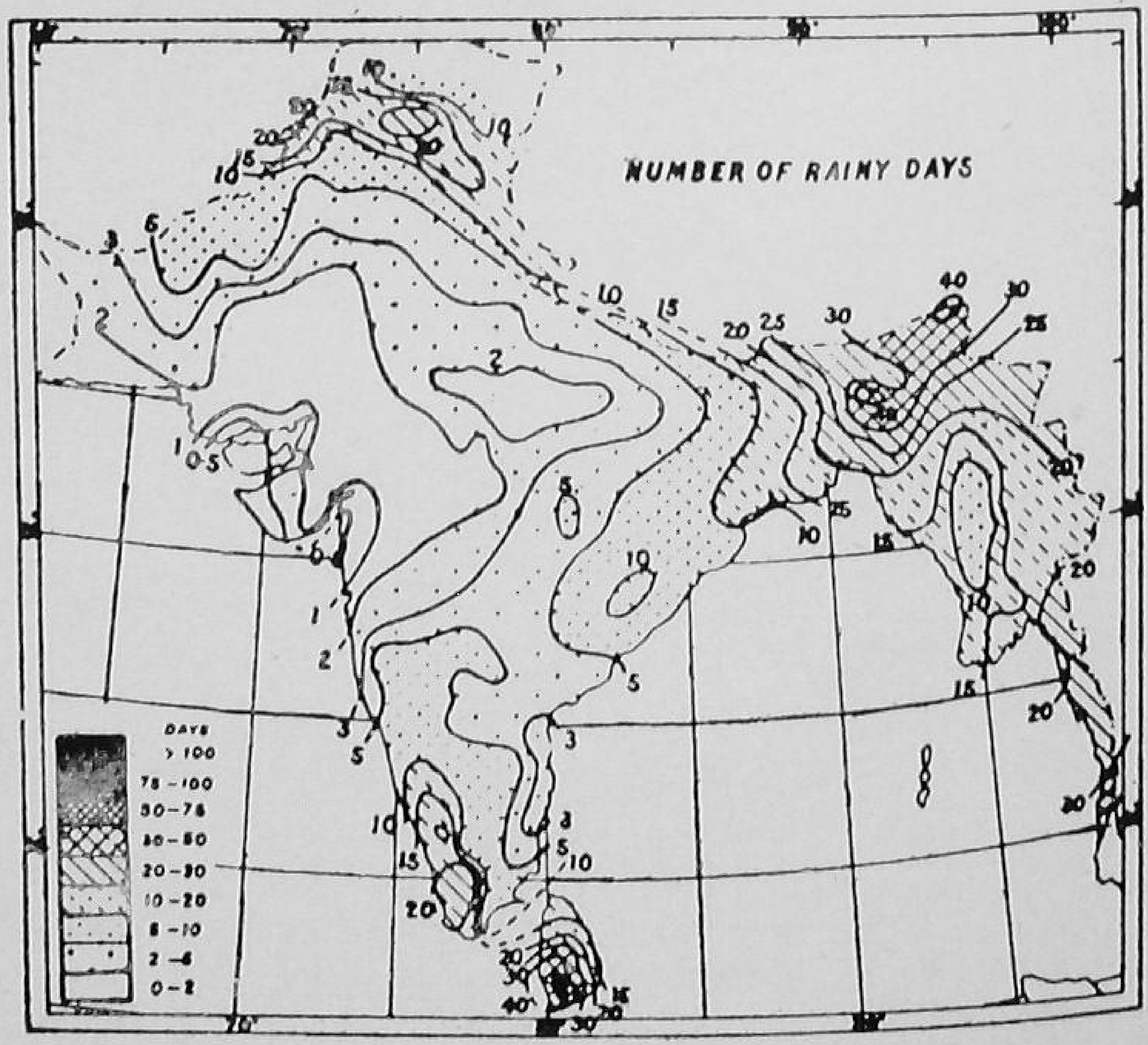


Fig. 9



Figs. 8 and 9
Seasonal rainfall and number of rainy days, March to May

Locally in India, grassland may be found as an edaphic climax on wet soils and in frost pockets in the *sal* belt and in the hills elsewhere, frost and excessive moisture inducing a 'grassy climax' (Champion and Griffith, 1948), but these circumstances do not make these areas a climatic climax. Certain lower alluvial deposits carry extensive grasslands, some of which are believed to be a stage in the primary succession, particularly those in the wetter and drier sites which trees cannot colonize. *Saccharum spontaneum* dominates the beginning of primary succession on sandy alluvial deposits. More generally, however, the grasslands on the lower alluvial deposits are a sequel to felling, burning and grazing ; those on the higher alluvium are also biotic in origin, being the result of human settlement and destruction of forests. The regeneration of forest is prevented by fire, grazing and cutting, and by general deterioration of the soil. Extensive areas in the *sal* belt which have suffered this treatment in the past now carry high savannah grasses, e.g. on the higher phantas of Kheri and the chaors of Haldwani in Uttar Pradesh (Champion and Griffith, 1948).

There are extensive grass downs on the Nilgiri, Palni and Anamalai plateaux in Southern India, where grazing and burning have been regularly practised. Discussing the ecology of the Nilgiri grasslands, Ranganathan (1938) argues that even more intensive grazing and burning elsewhere have not produced similar grasslands, that these Nilgiri grasslands owe their origin to frost as a major climatic factor, and they should, therefore, be regarded as a climatic climax in common with the local *sholas* (temperate wet evergreen type of forests). On the other hand, Bor (1938) contends that, once the existence of grazing and burning is admitted, the term 'climatic climax' cannot be applied to the community under any system of terminology ; these grasslands can, therefore, be considered only as a biotic climax. Holmes (1951) considers that the grasslands of Ceylon, which have much in common with those of India, are also 'secondary and of biotic origin, arising from clearing, burning and cultivation, and later, after abandonment, by periodic burning'.

With the existing evidence, and until the grassland survey of India is complete, we feel justified in concluding that grasslands do not occur as a climatic climax in India ; that in ecological jargon they generally represent secondary seres and rarely also priseres, and that, wherever they are relatively more stable, they constitute a biotic climax or, in Clementsian terminology, a disclimax more frequently of the nature of a sere-climax than of a sub-climax maintained

under the influence of fire and grazing in varying intensities and combinations.

Parallelism Between Grassland Types and Forest Types

It would be important to know, for the purpose of rapid reconnaissance surveys and the mapping of grassland types, whether any degree of parallelism in succession exists between these grassland types and the forest types of India as outlined by Champion (1935). In this connection, we should note in passing the ecology of these forest types. Human activities have played a very important part in moulding them. Again we have the three major factors ; fire, shifting cultivation and grazing, all of which tend to have a desiccating effect on the forest and help to hold back succession at an earlier stage. The significance of this will be appreciated if it is realized that the forests of economic importance in India are generally all in the seral stage. The wet evergreen forests—the only types which can be given the status of a definite climatic climax—contain few species of economic importance Champion (1935) observes "Forest management consists largely in maintaining a forest in the seral stage in which it is economically most valuable, and that is relatively rarely the climax stage". By and large, the forests of teak, *sal* and most of the other valuable Indian species are seral types.

Most of the existing grassland types of India which are described in Chapter VI are also seral in nature. Any attempt to correlate them implies, therefore, a comparison of two different types of vegetation, each probably in a different and individual characteristic stage of succession under the influence of the tropic features in varying combinations and intensities.

The subject is not one which has yet been studied in any detail, although it will obviously receive careful attention by the Grassland Survey Team, which contains forest officers in addition to agronomists and grassland ecologists.

Hole (1911) appears to have been the first to raise the question of parallelism between woodland and grassland in India. He mentioned parallel succession as one of the types of succession, citing as an example the fact that *Saccharum munja* exists as a parallel grass type to woodland of *Acacia catechu* and *Dalbergia sissoo* under similar conditions. Hole considered that types of grassland and woodland are found in all kinds of habitats, ranging from the most xerophytic to the most hygrophytic, that for every type of grassland there is generally a corresponding type of woodland and that changes from a grassland

PLATE III

Typical association of grasses in a moist ditch in the Terai. The grasses are : *Coix lachryma-jobi* (bottom left corner), Kans or *Saccharum spontaneum* (right corner in foreground), *Sorghum halepense* (in left background) and *Saccharum spontaneum* with flowering spikes (in right background)

Photo ; D. Chatterjee.

Fig. 10

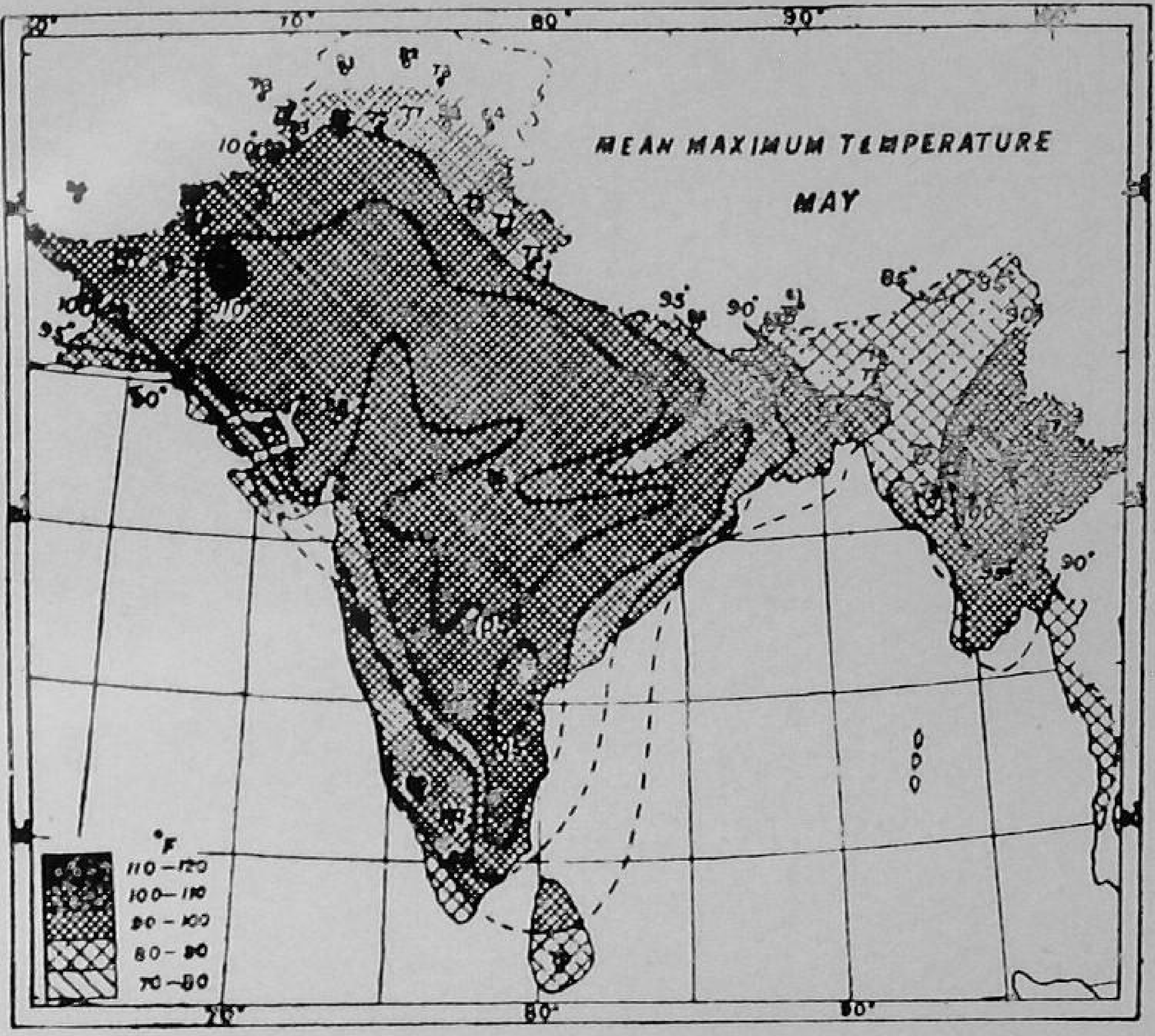


Fig. 11

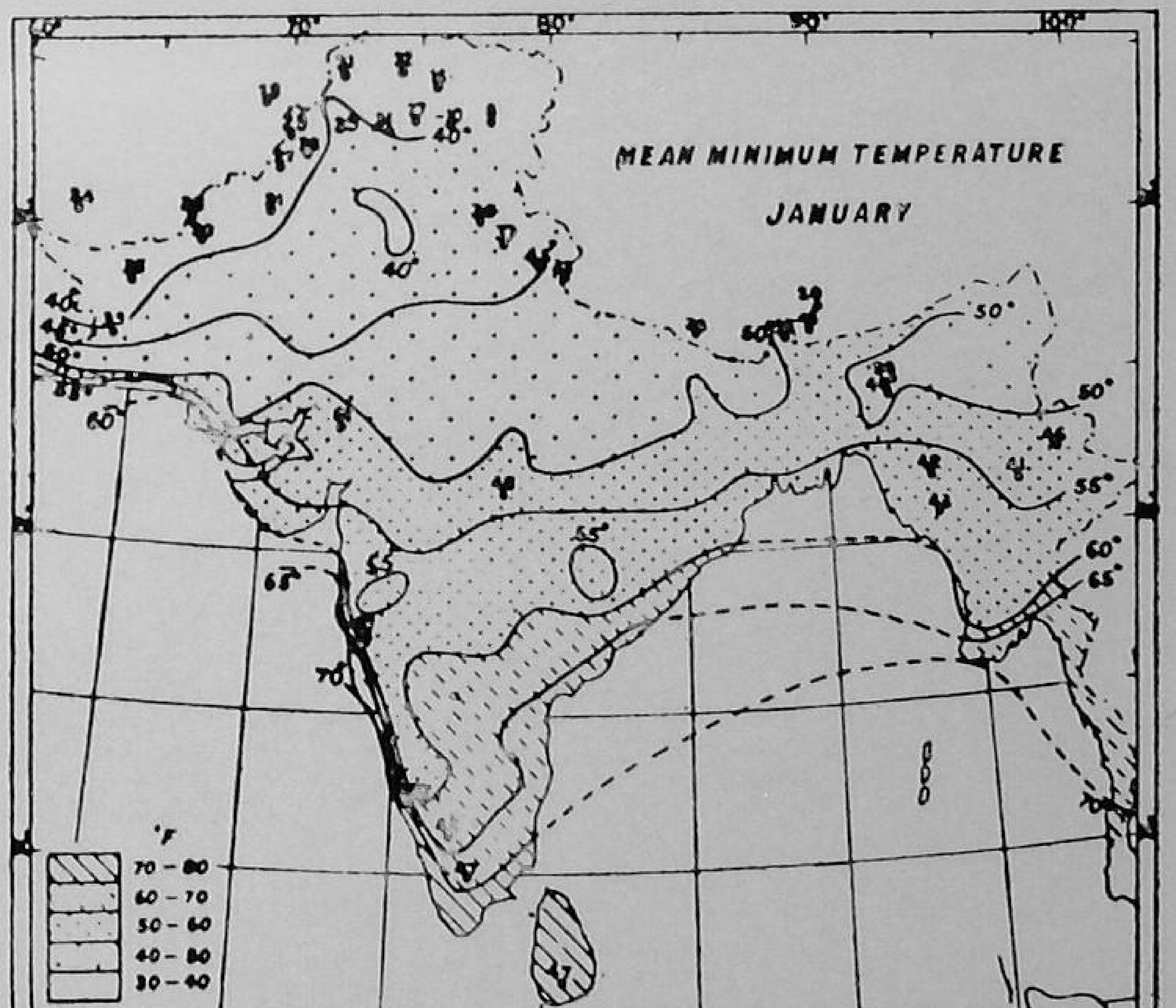


Fig. 10 and 11

Maximum temperature in May and mean minimum temperature in January

type to a corresponding woodland type and *vice versa* can be effected easily and rapidly.

As an example of parallel succession, Hole cited *Saccharum munja* colonizing an area of recent alluvium and subsequently yielding place to a pure stand of *khair* (*Acacia catechu*), the 'corresponding' woodland type. Following up this approach, Hole evolved a scheme of classification of these groups of parallel woodland and grassland types of vegetation corresponding to 'xerophilous', 'mesophilous' and 'hygrophilous' habitats, the two types in each group being mutually replaceable.

(*a*) 'Dry Deciduous' forests and the 'Steppes'

(*b*) 'Deciduous' and 'Hill' forests, including the majority of coniferous forests, and the 'Meadow' or 'Moist Savannah' and

(*c*) 'Tropical Evergreen' forests, and 'Wet Savannah' and 'Reed Swamp'.

Troup (1921) subscribed to Holes' hypothesis by referring to certain grassland types and parallel woodland formations, namely

Saccharum munja and *Acacia catechu*,
Narenga porphyrocoma and *Shorea robusta*,
Saccharum procerum,
Phragmites karka, etc. and *Albizzia procera*,
Bischofia javanica.
and *Salmalia malabarica* (*Bombax malabaricum*).

There is much in Hole's thesis that cannot now be accepted, for example, the fact that the climax formation in any site might be either grassland or woodland ; this has been refuted by modern ecologists (Weaver and Clements, 1938, Oosting, 1948, and Braun Blanquet, 1932). Even in respect of the seral stages, one cannot accept the implied suggestion of identity or at least close similarity of environmental conditions obtaining in different sites colonized by 'parallel' woodland and grassland types, and in the same site when a 'parallel' type of succession takes place in it. In a forest climate, edaphic conditions favourable to the growth of grasses only may lead to the initial formation of grassland, but such conditions are usually only transitory ; the grasses contribute to their own undoing by adding humus to the soil and thereby inviting tree species to supplant them (Bor, 1947).

Grasses may predominate in a forest climate because of the operation of the biotic factors also, but once these are removed soil changes occur which pave the way for the elimination of the adventitious grasses and their replacement by tree growth. In either case, soil changes mark the transition from one to the other; it is, therefore, difficult to understand how grasslands in a forest climate can exhibit any constant parallelism with woodlands in different developmental stages in the full range of environmental conditions. In classifying the areas as 'xerophilous', 'mesophilous' and 'hygrophilous' respectively and assigning parallel woodland and grassland types to them. Hole has equated in terms of climate and not made sufficient allowance for edaphic variations.

Parallelism between grasslands and woodlands may, however, be conceived in a different light. Stages in primary and secondary succession in a forest climate are likely to be marked by parallelism between the tree dominants on the one hand and the associated chief grasses on the other. The grassy undergrowth of a forest with an open canopy must be different from that with a closed canopy; Bor (1947) considers that, in all these habitats, the grass covering appears to be in harmony with the surroundings and is relatively stable as long as growing conditions are not changed. This suggests that each forest type should carry certain grasses corresponding to its tree dominants. A knowledge of both would prove of value in adjusting grazing management in forests, but information concerning forest grasses in relation to the forest types is rather meagre.

Champion (1935) gives detailed information concerning the dominant trees, but makes little reference to the grasses. For the purpose of the present study the forest types of India were tabulated in a printed condensed form and circulated to all Forest Departments with a request that they fill in the last column provided for listing the grasses associated with each forest type. This information can be regarded as only provisional pending the completion of the grassland survey. The information collected to-date will be published separately by the Forest Research Institute.

Grasses as Site Indicators

It follows from the suggestion of parallelism between tree dominants and associated grasses that the existence of certain grasses should indicate the relative suitability of a given site for certain tree species, or that these or other tree species will come in if the intensity of the biotic factors is reduced or

PLATE IV

Typical *Phragmites*/*Saccharum* type of grassland in the Terai area, Uttar Pradesh

Photo : D. Chatterjee

eliminated. A good example is *Narenga porphyrocoma* as an indicator for *sal*. *Phragmites karka* and *Arundo donax* indicate conditions too wet for all except a few species such as *Bischofia javanica*, *Trewia nudiflora* and *Putranjiva roxburghii*. *Erianthus ravennæ* would appear to indicate moist mixed forest conditions suitable for *Lannea grandis*, *Butea frondosa*, *Gmelina arborea*, *Cedrela toona*, *Mallotus philippensis*, *Terminalia tomentosa*, *Kydia calycine* and *Bombax malabaricum* (Troup, 1926). Recorded observations do not cover all the different forest types.

Grasses should in a general way indicate the condition and potential value of sites. Bor (1947) has grouped the grasses of Uttar Pradesh as indicators of very dry, dry, moderately moist and wet localities. Kulkarni has made a similar study of the grasses of the worn-out pastures of Bombay Deccan (1926).

Indicators of Heavy Grazing

Certain plants are valuable in indicating the intensity of the biotic factors. The following species are avoided by cattle and, therefore, indicate excessive grazing and browsing when they form the chief species in a stand: *Butea frondosa*, *Holarrhena antidysentrica*, *Caseria tomentosa*, *Lagerstroemia parviflora*, *Strychnos nux-vomica*, *Woodfordia fruticosa*, *Cleistanthus collinus*, *Mallotus philippensis* and many other species of Euphorbiaceae, *Dodonea viscosa* and *Adhatoda vasica* (Troup, 1926). Armed species like *Carissa spinarum*, *Zizyphus jujuba* and *Z. oenoplia* frequently over-run heavily grazed areas. Overgrazed grasslands in Bengal have been occupied by *Careya herbacea*, and in Madhya Pradesh by *Xanthium strumarium* (Bor, 1942). The poisonous grass, *Oryzopsis aequiglumis*, is spreading fast in the temperate regions of Kashmir; under the prevailing heavy grazing, it is the only grass that is allowed to seed, and its eradication is one of the major grazing problems of the State (Silv. Conference 1951). Severe overgrazing of village grazing grounds and similar land is indicated by the presence in excessive numbers of unpalatable species such as *Capparis aphylla* (eroded tracts west of Delhi) and the legumes, *Cassia occidentalis*, *C. auriculata*, *C. tora*, *Tephrosia villosa*, *T. purpurea*, *Prosopis spicigera* and *Crotalaria medicaginea*. These species indicate over-grazing, erosion, desiccation, infertility and poor moisture status of the soils.

Action of Biotic Factors

Frequent reference has already been made to the action of the biotic

factors, shifting cultivation, fire and grazing, in creating the present grassland types of India. The variations in types of grassland produced in a locality are determined by the way these factors operate in combination with other factors of the site.

Shifting cultivation following forest clearance has reduced tree-covered hillsides to grassy slopes in Assam (Bor, 1942) and many other parts of the country. Factors which decide the further succession in abandoned clearings are the climatic conditions, the nature of the cleared forest growth and of the surrounding vegetation, the nature and duration of the shifting cultivation and the subsequent exposure of the regrowth to fire and grazing.

Even in high rainfall areas where a tree regrowth normally becomes established readily after temporary cultivation, a period of prolonged cultivation, the absence of conditions favouring coppice or seedling regeneration, and a marked incidence of burning, grazing and lopping following the cultivation will result in the establishment of a grassland. Shifting cultivation under conditions of poor rainfall or a long dry season, or where grasses reseed readily, will lead to the replacement of tree growth by grass. The type of grassland formed will depend principally on the availability of propagules and on the conditions of soil moisture resulting from the cultivation and accessory factors, rank coarse grasses appearing in certain conditions and short and relatively palatable ones in others.

Fire is the chief factor which keeps many former forest tracts in the condition of savannahs and grasslands. Only a few tree species can withstand repeated fire damage and even these may be killed out in years of severe drought. Perennial fibrous unpalatable grasses are then able to become established and to flourish ; although fire may burn the above-ground stems and leaves, the growth of the underground parts is stimulated, at least temporarily. Fire also removes the competition of annual weeds. With burning alone or in combination with the insignificant grazing of wild animals only, this kind of tall grassland is the usual result. When cattle grazing is combined with burning to produce fresh edible shoots of the tall fibrous grasses, the rhizomes may be killed out and the grassland assumes a depauperate form. Burning and a high incidence of grazing, therefore, produce the short turf grassland, probably with species such as *Imperata cylindrica* (Bor, 1942, 1947).

Closure of seral grasslands has the effect of starting the progression towards the climax. In a woodland climax this would mean ultimately the elimination of grasses by a higher form of vegetation. In badly denuded areas, closure up to a limit may help to bring back useful grasses, but closure does not always increase the proportion of palatable grasses, particularly where the area to be closed has already a good grass cover. In estimating the possible effect of closure in any area, one should know the present seral stage, the rate of progression following the closure, and the expected stages of succession (Bor, 1942).

CHAPTER VI

THE GRASSLAND TYPES

WE have in the preceding chapter indicated the present consensus of opinion concerning the place of Indian grasslands in relation to the natural vegetation in general and the forests in particular. We now turn to the grasslands themselves. Indian and other botanists have done much valuable work on the recognition, naming and classifying of the great number of grass species of India. Dr. N. L. Bor is at present engaged on a major work on this subject for publication by the Indian Council of Agricultural Research. Relatively little attention has, however, been given to the grassland associations as they occur and change in relation to the ecological factros of the environment, natural or induced.

In order to obtain a preliminary picture of the grassland types of India, a review has been made on the basis of personal experiences and observations in the field, combined with such information as could be obtained from the scattered literature, reports from the States and incidental references to the subject. For the benefit of those who find ecological jargon and botanical nomenclature unpalatable, a brief summary of the preliminary conclusions reached will be given before proceeding to discuss the details.

This grouping of grassland associations has been made on the basis of the map of the agricultural and animal husbandry zones of India (Fig. 12). It may be thought that this purely botanical study has little application to the practical problems of feeding India's livestock. But that which we may term ecological management of grassland is the chief, if not the only, method which can be adopted in India for grazing grounds, village pastures, forest grazings and similar uncultivated and uncultivable areas. Before recommendations can be made regarding the possible effects of adjustments of grazing intensity and duration on any village pasture, it is necessary to have available certain basic information regarding the botanical composition and ecological succession of the characteristic grassland type of the area. So far we are able to give only general indications; the essential and complete data will be provided by the Grassland Survey of India.

It is now possible tentatively to recognize about eight major types of grassland in the plains, hills and mountains as follows (the first four types are characteristic of the plains, the last four of the hills and mountains) :

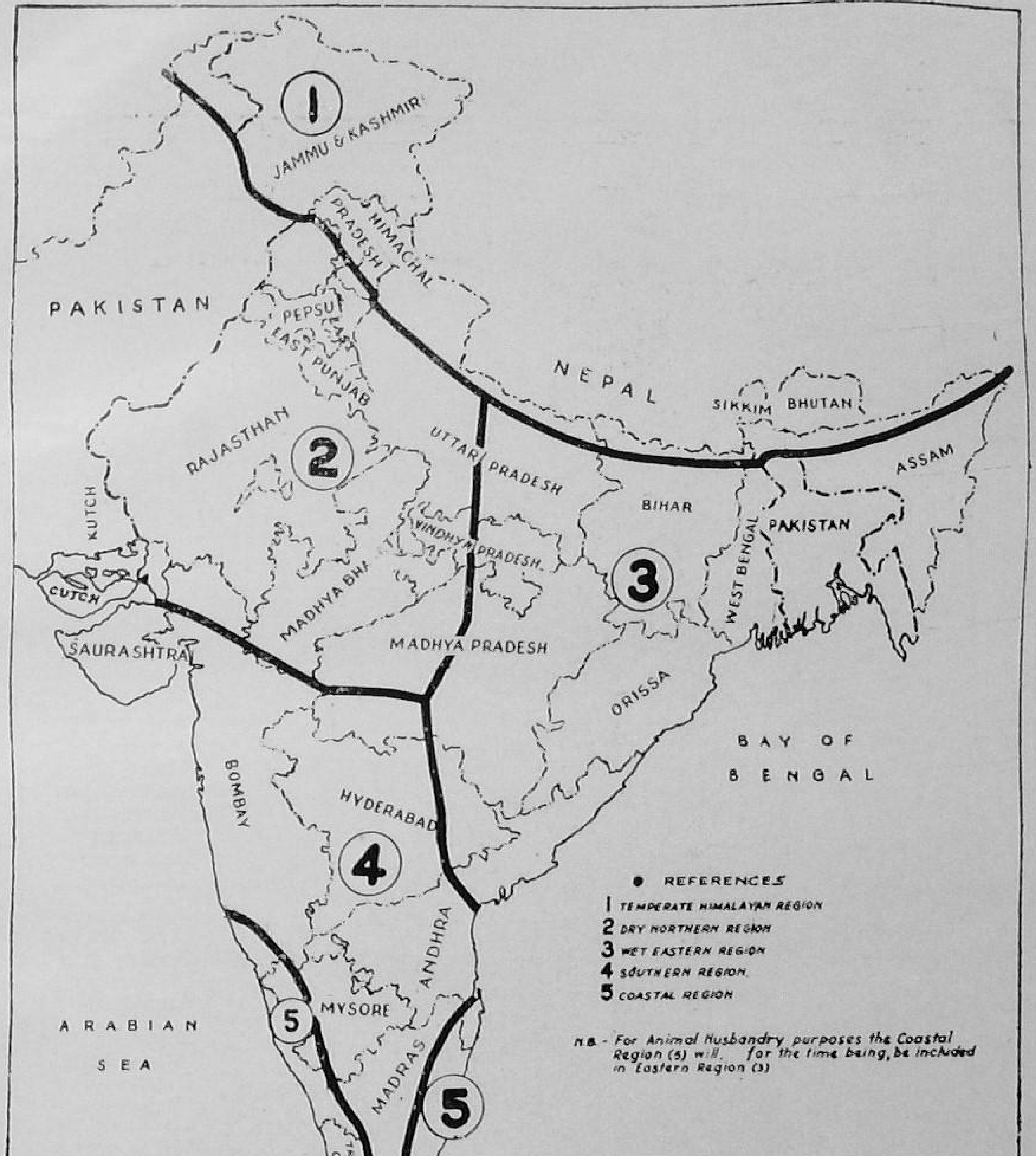


Fig. 12

Agricultural and animal husbandry regions of India

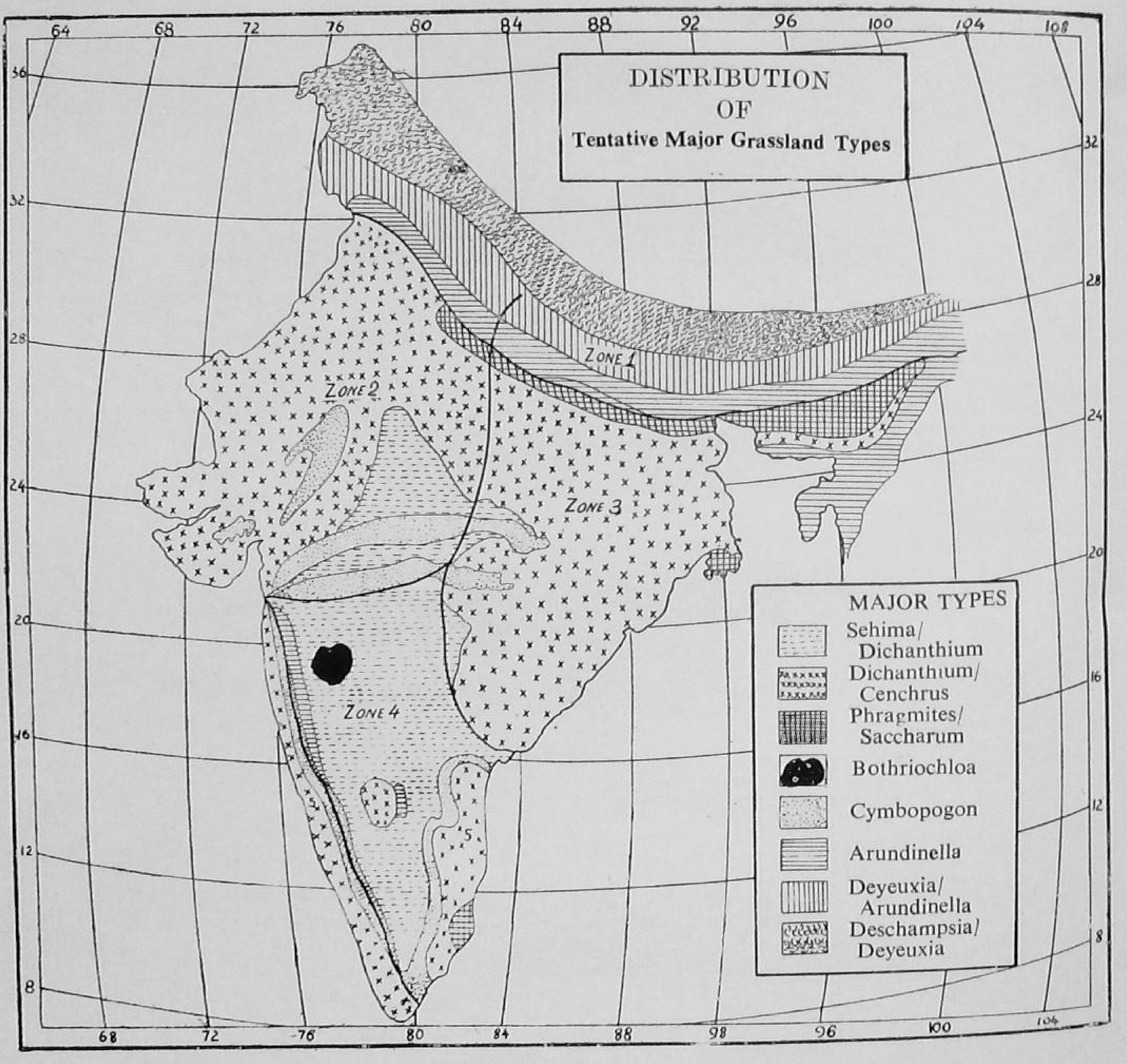

DISTRIBUTION
OF
Tentative Major Grassland Types
ZONE 1
ZONE 2
ZONE 3
ZONE 4
5
MAJOR TYPES
Sehima/ Dichanthium
Dichanthium/ Cenchrus
Phragmites/ Saccharum
Bothriochloa
Cymbopogon
Arundinella
Deyeuxia/ Arundinella
Deschampsia/ Deyeuxia

Fig. 13

Plate V

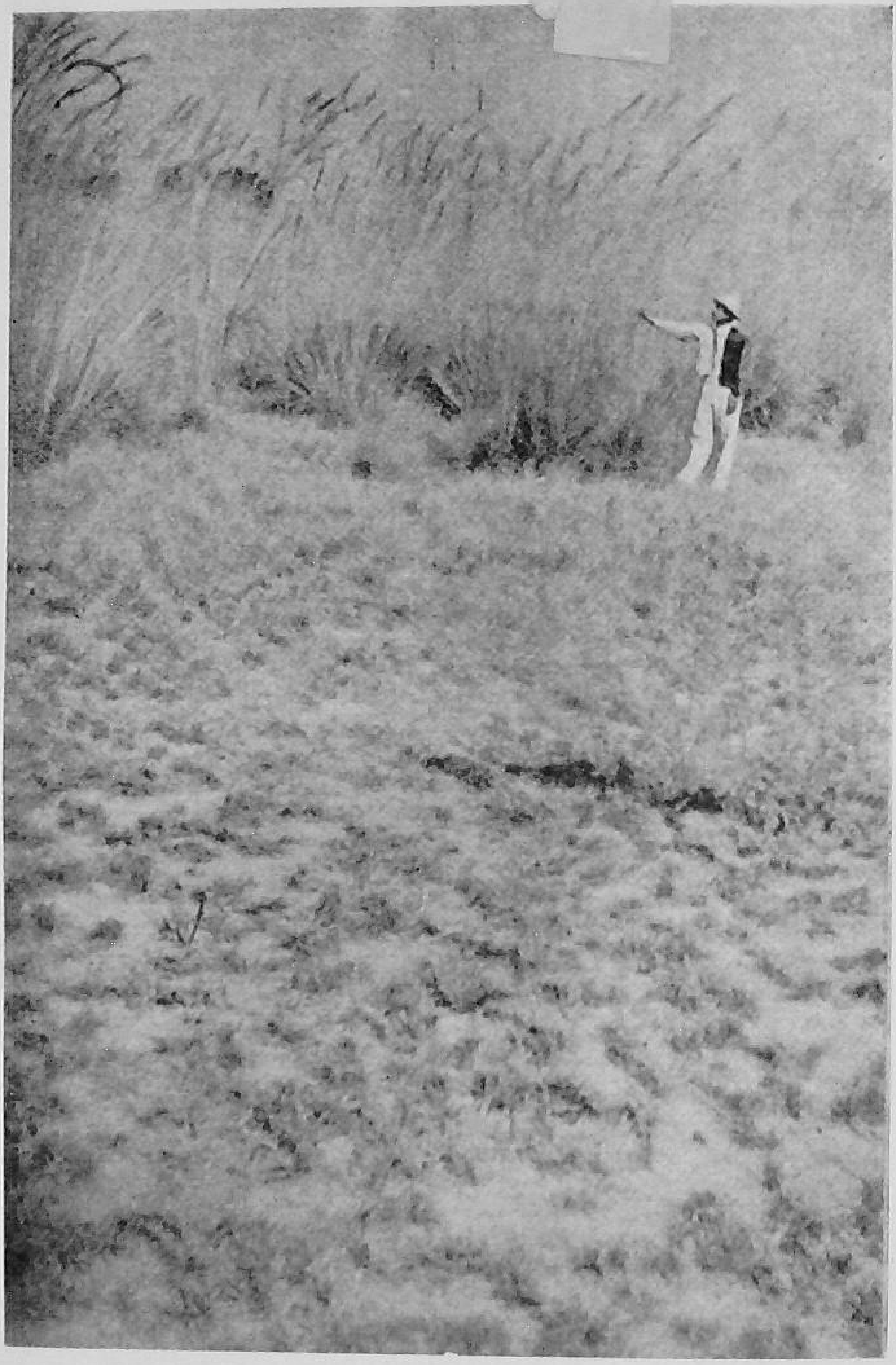
The regression of the *Phragmites/Saccharum* type into *Vetiveria* sub-type as a result of annual burning and grazing. The tree associates are *Acacia mimosoides* and *A. arabica*

Photo : ICAR Grassland Survey Team

A typical *Sehima Dischauthium* grass and type in Andhra, showing the presence of *Sehima nervosum* on gravelly soils, together with *Chrysopogon montanus*, *Eremopogon foveolatus* and *Heteropogon contortus*. Light grazing has been responsible for the maintenance of a good stand of *Sehima nervosum*

Photo : ICAR Grassland Survey Team

PLATE V—(. . . l.)



Desmotachya sub-type representing the last stage of regression in the *Phragmites saccharum* type. The grazed species in the foreground is *Desmotachya bipinata*, that in the background *Saccharum bengalense* (Munj)

Photo : I. C. A. R. Grassland Survey Team

Grassland type	Environment
Sehima / Dichanthium	Black soils
Dichanthium / Cenchrus	Sandy loams
Phragmites/ Saccharum	Marshy localities
Bothriochloa	Paddy tracts and high rainfall belt
Cymbopogon	Low hills
Arundinella	High mountains
Deyeuxia/Arundinella	Mixed temperate climate
Deschampsia/Deyeuxia	Temperate alpine climate

Whenever the biotic factors of burning, grazing, cutting and shifting cultivation are in operation to any extent, these major types are replaced by a series of regressive types which vary according to the intensity of the biotic factors. These subtypes are the ones now generally seen in field inspections; as already stated, their relationship to one of the major types and to associated subtypes must be known and understood by anyone concerned with improving grassland (Table XVIII).

Fig. 13 prepared on the basis of this review should be regarded as giving only a provisional indication of the distribution of the major grassland types. The distribution of the tentative grassland types in the different States in India is given in Table XIX. It will obviously be considerably revised when the Grassland Survey is completed. An indication of succession in five grassland types is given on page 110, based on the results of the first 2 years of the survey.

Grassland Types in Agricultural Zone I

Zone I comprises the mountain wall formed by the Himalayas, including the north-east part of the Punjab, the whole of Himachal Pradesh and Kashmir, and the northern districts of Uttar Pradesh, Bihar, Bengal and Assam. A strip of country about 1,000 miles long and 30 to 40 miles wide lying nearer the Indo-Gangetic plains constitutes the Terai of Uttar Pradesh and the Duar of West Bengal. This region is characterised by swampy soils, and a rainfall varying from 40 inches in the west to over 100 inches in the east. The Terai region proper does not occur in the western part of the zone.

Nearer the Himalaya, a second strip consists of a belt of hills including such groups as the Ghuria Ghati of Nepal, the Dun Hills of Northern Bihar, the Sinchula Hills of Northern Bengal, the Siwalik Hills to the north of Delhi, as well as the lower slopes of the outer Himalayas. These ranges of foot-hills do not

generally exceed 4,000 feet and are usually covered with moist deciduous forest, with *sal* (*Shorea robusta*) as the characteristic species. *Sal* flourishes especially on the fans of coarse gravel which have been brought down from the hills and are known as *Bhabar*. The forest is interrupted by large patches of coarse grass as in the Terai. The western part of the *Bhabar* has a rainfall of 30 to 40 inches, is much drier than the eastern part, but still has a heavier rainfall than the adjacent plains. The outer and lower strips in the western part include foot-hills such as the Siwalik Hills and mountain slopes up to 3,000 feet, usually covered with a dry deciduous or scrub type of forest. The second strip on the western part extends from 3,000 to 5,000 feet where *chir* pine (*Pinus roxburghii*=*P. longifolia*) is very common. The outer Himalaya is between 5,000 and 10 000 feet. The forest is characterised by temperate species; these cover the northern slopes in drier parts, while the southern slopes are often bare and stony or covered with grass and shrubs.

The grassland types found in Zone I are mainly related to altitude.

Foot-hills. The Terai area lying at the foot-hills of the Himalayas and characterized by moist to swampy conditions, with loamy to heavy soils, represents the tall savannah. The grassland type is predominantly mesophilous to hygrophilous, with coarse grass species such as *Phragmites karka*, *Narenga porphyrocoma*, *Arundo donax*, *Saccharum bengalense*, *Saccharum spontaneum*, *Themeda arundinacea*, *Imperata cylindrica* and *Vetiveria zizanioides*. From the dominance of the first two species and constant association of *Saccharum* species, this major type may be recognized as the *Phragmites/Saccharum* type.

This type represents the highest stage of development of grasses under the conditions of the Terai. Under the influence of biotic factors, it degenerates into many subtypes. The heavy grazing and annual fires to which it is subject induce drier conditions, a reduction in soil moisture and corresponding changes in the grass flora.

The first species to disappear under the biotic influence are *Phragmites karka* and *Arundo donax*. *Narenga porphyrocoma*, *Saccharum bengalense*, *Themeda arundinacea*, *Erianthus ravennae* and *Imperata cylindrica* become dominant, with scattered colonies of *Saccharum spontaneum* and *Vetiveria zizanioides*. The predominance of *Narenga* and *Erianthus* makes this a distinct subtype which may be designated as the *Narenga/Erianthus* subtype. Hole (1911) remarks that *Narenga porphyrocoma* savannah is usually well-marked, but sometimes occurs in association with

Erianthus ravennae and *Saccharum bengalense* Such an admixture is brought about in the lighter soils of the area by the felling of *sal*. The soil gradually loses its capacity to hold sufficient water and becomes dried by exposure to sun and air. *Saccharum bengalense* eventually becomes dominant if regeneration of woodland is prevented.

Continued operation of the biotic factors leads to the gradual disappearance of the dominant *Narenga porphyrocoma* and *Saccharum* species, and their replacement by *Vetiveria zizanioides*. The *Vetiveria* subtype perhaps represents the last stage of regression of the tall savannah, as further grazing and burning leads to complete denudation of the vegetative cover. Such conditions have been noted in the grazing compound of the Banbasa canal colony in Uttar Pradesh. The bare patches are not, as might perhaps have been expected, invaded by more prostrate forms such as species of *Eleusine*, *Paspalum* and *Cynodon*.

The drier conditions caused by annual burning and grazing lead to a succession of typical xerophytic vegetation, through the appearance of a mixed association of *Apluda aristata* and *Dichanthium annulatum* and ultimately to the establishment of pure colonies of *Heteropogon contortus*. It will be seen from the description of the grassland types in Zones II and IV that *Heteropogon* is invariably dominant when grasslands are subjected to periodic burning ; it remains more or less stable under these conditions and, therefore, represents a distinct retrograde type which may be recognised as the *Heteropogon* subtype.

Lower Himalayan region (up to 6,500 ft.)

With a change in altitude, the grass species in the *Phragmites/Saccharum* type of grassland more or less disappear, giving place to xerophytic grassland in which *Chrysopogon montanus* and *Eulaliopsis binata* are the dominant species, with some admixture of species of *Arundinella*, *Pennisetum*, *Apluda* and *Heteropogon*. The *Chrysopogon* subtype extends to an elevation of 4,500 ft.

In his study of grassland types in Dehra Dun, Saharanpur and the southern slopes of the Siwaliks, Hole (1911) noted a xerophytic association consisting of *Chrysopogon montanus*, *Aristida cyanantha*, *Neyraudia* sp., *Saccharum spontaneum*, and *S. bengalense*, the last two in their xerophilous forms. The association is obviously a continuation of the *Chrysopogon* subtype described above. The desert community composed of species of *Aristida*, which occurs on coarse shingle and gravel exposed by the running water, probably represents the lowest degraded

form of the *Chrysopogon* subtype. This *Aristida* subtype also finds a parallel in Zone IV.

Above 4,500 feet, the *Chrysopogon* subtype merges into a major type characterized by species of *Arundinella* with a fair proportion of species of *Themeda* and *Chrysopogon*. *Arundinella nepalensis* and *A. setosa* are very common. *Themeda anathera* is the most common species of that genus, while *Chrysopogon* is represented by *C. montanus*, *C. aciculatus* and *C. gryllus*. This type is characteristic of hilly tracts and high mountains and is, therefore, regarded as a major type; because of the dominance of *Arundinella* species, it is called the *Arundinella* major type.

Upper Himalaya

The change from sub-tropical to temperate conditions around 6,500 feet in this region is naturally accompanied by parallel changes in the grass vegetation. Thus at Simla, a mixed association of sub-tropical and temperate grass species occurs. Common sub-tropical and tropical species are *Arundinella setosa*, *Themeda anathera*, *Pennisetum orientale*, *Chrysopogon gryllus*, *C. montanus*, *Apluda aristata*, *Heteropogon contortus* and *Dichanthium annulatum*. The temperate species include *Deyeuxia scabrescens*, *Stipa* sp., *Phleum* sp., *Agrostis* sp., *Helictotrichon asperum*, *Danthonia* sp., *Poa pratensis*, *Festuca kashmiriana*, *Agropyron longearistatum* and *Agropyron semicostatum*. The grassland association found in Simla is, therefore, mixed temperate and may be recognised as the *Deyeuxia/Arundinella* major type.

Duthie (1890) reports that "on reaching an elevation of 7,000 or 8,000 feet, sub-tropical forms are gradually lost sight of and the majority of the species are found to be characteristic of temperate climates, many European genera such as *Deyeuxia*, *Helictotrichon*, *Brachypodium*, *Bromus*, *Dactylis* and *Festuca* being represented. At still higher elevations and up to the limit of melting snow we meet with many species identically the same as occur on the mountains of Europe and America and along the shores of countries in the Arctic region."

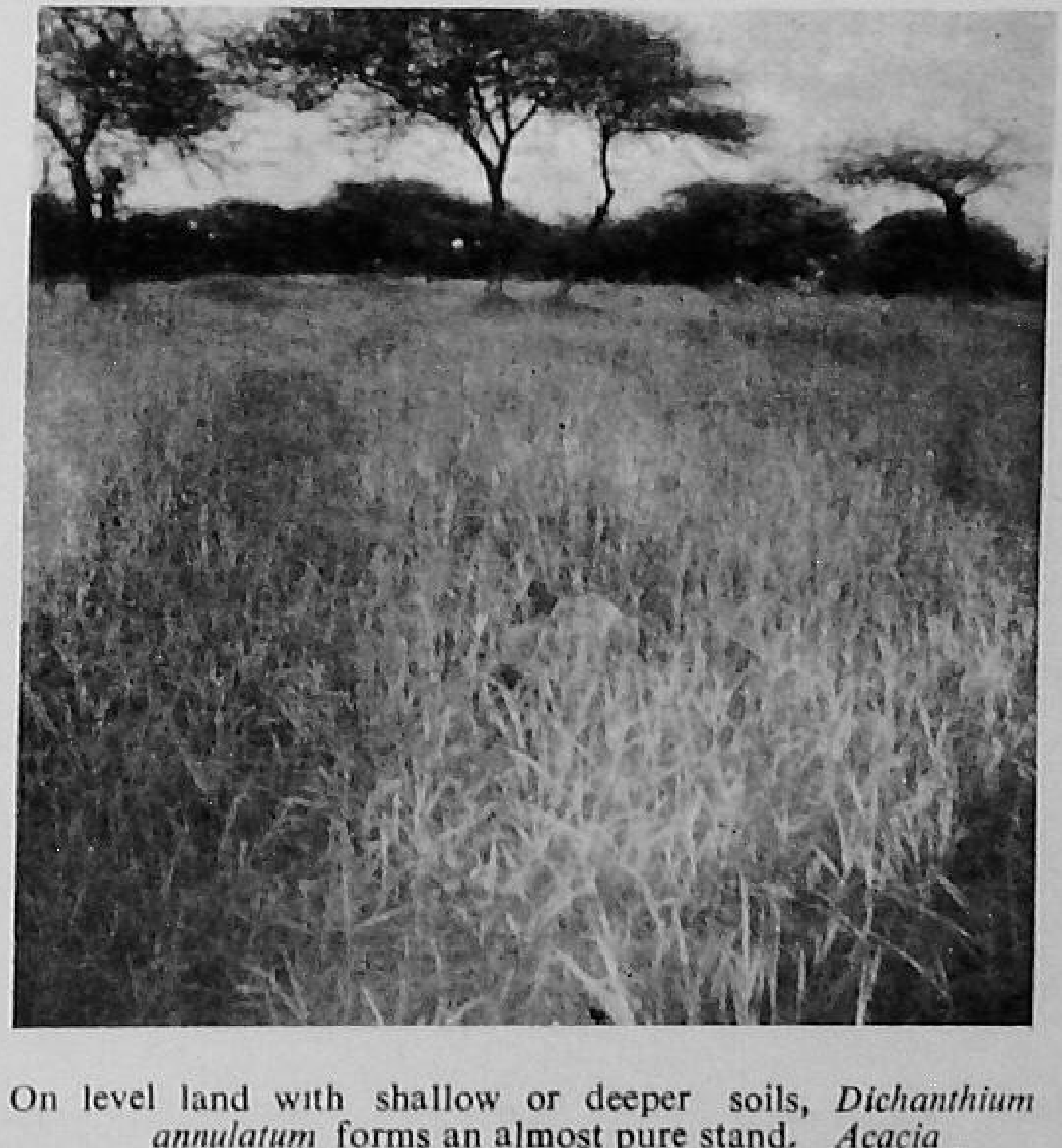
Alpine and sub-alpine Region

Smith (1913) recorded the following genera in the alpine and sub-alpine vegetation of Southeast Sikkim, between 10,000 to 16,000 feet: *Deyeuxia*, *Deschampsia*, *Poa*, *Hierochloa* (two species), *Stipa*, *Agrostis*, *Calamagrostis*, *Helictotrichon*, *Glyceria* and *Festuca*. *Deyeuxia scabrescens*, *Deschampsia caespitosa* and *Poa pagophila* are common. No leguminous plants were observed in the grasslands apart from *Astragalus sikkimensis* which occurred sparingly at

PLATE VI

Sehima nervosum with *Heteropogon contortus* in grassland at Jhansi, Uttar Pradesh

Photo : ICAR Grassland Survey Team



On level land with shallow or deeper soils, *Dichanthium annulatum* forms an almost pure stand. *Acacia arabica* is the associate tree species

Photo : ICAR Grassland Survey Team

14,000 feet. Smith and Cave (1913) further observed that grasses were rare at 16,000 feet. *Deschampsia caespitosa* and *Trisetum spicatum* were frequent. Other genera were *Miscanthus, Oryzopsis, Phleum, Catabrosa, Eragrostis nigra* and *Agropyron longearistatum*. This temperate grassland may be recognised as the *Deschampsia/Deyeuxia* type.

"Although very little is known concerning the nutritive value of Himalayan grasses individually, it is nevertheless certain that excellent pasturage is obtainable at every elevation during certain seasons of the year. The wide open stretches of grasslands (*maidans*) extending from the upper limits of the forests towards the snow line constitute the finest feeding grounds for cattle and sheep during the summer months. Many of the grasses which flourish in these elevated meadows are known to be highly prized constituents of the best European pastures and with them are found many allied species which analysed would no doubt prove to be equally valuable" (Duthie, 1890).

The hilly areas in the north-east of the Punjab, comprising the Kangra and Kulu divisions, have xerophytic grasslands. The association consists of *Pennisetum orientale, Themeda anathera, Chrysopogon montanus, Cenchrus ciliaris, Bothriochloa pertusa, Heteropogon contortus* and *Dichanthium annulatum*. The first three species show affinity with the sub-tropical association found in Simla. The remaining species appear to represent a continuation of the *Dichanthium* type described in Zone II.

Grassland Types in Agricultural Zone II

Zone II comprises the Punjab plains southwest of the Himalayan foot-hills, and Delhi, Rajasthan, Western Uttar Pradesh. Saurashtra, Gujarat, Madhya Bharat and Madhya Pradesh. Except for its southern portion, the Rajput uplands, which is bounded on the south by the Vindhya ranges and on the north-west by the Aravali ranges, the zone consists of the western portion of the 'Great lowland plains'. On a rainfall basis, the zone may be roughly divided into three regions, namely, the northern semi-arid region with a rainfall between 20 to 30 inches; the southwest plains with less than 10 inches and the southeast portion with about 40 inches. The soil of the arid and semi-arid region is sandy alluvium with many alkaline patches, while the southeast portion has black loamy soils. The grassland types vary according to both topographic and edaphic factors.

The semi-arid region in the north is generally characterized by an open xerophytic thorny vegetation with *Zizyphus*, *Prosopis spicigera*, *Acacia*, and *Capparis aphylla* as the dominant thorny shrubs. Other bushy vegetation consists mainly of *Tephrosia purpurea*, *T. villosa*, *Crotalaria medicaginea*, *C. burhia*, *Cassia occidentalis*, *C. auriculata* and *Calotropis procera*. These species of *Tephrosia* and *Crotalaria* are generally associated with abandoned fields. The tract has some of the best grassland types in India and is associated with well-known breeds of cattle (Hissar, Hariana, Sahiwal, Tharparkar and Gir) and buffaloes (Murrah and Mehesana). Cattle husbandry is a very important industry in all the States. The superior grasslands of the Mehesana district of Bombay have been used for the dry dairy animals from Greater Bombay.

The grassland type on the sandy soil is characterized by the following perennial grasses : *Dichanthium annulatum*, *Cenchrus ciliaris*, *Cenchrus setigerus*, *Bothriochloa pertusa*, *Heteropogon contortus* and *Cynodon dactylon*; and the following annual grasses: *Eragrostis tremula*, *E. viscosa*, *E. tenella*, *E. ciliaris*, *Cenchrus biflorus*, *Aristida adscensionis*, *A. redacta*, and *Dactyloctenium aegyptium*. The Cyperaceae are represented by *Cyperus rotundus* and *C. bulbosus*.

Dichanthium annulatum and *Cenchrus ciliaris* are the most important economic grasses and are dominant in the tract. As the grasslands are subject to heavy and close grazing by cattle and sheep, they exhibit all stages of deterioration through a gradual disappearance of the perennial species to sparsely populated annual types of grassland, and ultimately to almost bare soils. As the soil is light in texture, it is liable to severe erosion in the later two stages. The Jamuna, Chambal and Sabarmati catchment areas bear witness to the devastating effects of overgrazing.

A detailed study of vegetation at Hirpura, in the Mehesana district of the former Baroda State (now Bombay State), has indicated the succession in grasslands associated with sandy soils. The village is situated about five miles from the river Sabarmati and was included in a soil conservation scheme of the Department of Agriculture of the former Baroda State. The study of vegetation was made in connection with the scheme for the 'Improvement of forest grass and prevention of erosion' financed by the Indian Council of Agricultural Research. Under the soil-conservation scheme the area was closed for grazing in 1942 and the study of vegetation was commenced in 1944.

Test quadrats showed that fourteen species were present. About 42 per cent of the total forage was contributed by the non-palatable *Aristida* and *Perotis* species, 29 per cent by the medium-quality *Eragrostis* species, and only 26 per cent by *Dichanthium annulatum*, *Cenchrus ciliaris*, *Digitaria adscendens* and *Cenchrus biflorus*. Non-gramineous plants included *Cassia auriculata* and *Tephrosia purpurea* as dominants, with *Cassia tora*, *C. occidentalis*, *Crotalaria medicaginea* and *C. burhia*. *Cassia auriculata* served as an indicator of overgrazing and dominated the communal grazing ground to the exclusion of all other vegetation.

The following broad stages in plant succession were observed when the area was closed in 1942. Bare patches are occupied first by *Cyperus bulbosus*, a tiny rapidly maturing plant about four to six inches high. Soil particles collect around the plant, and the interspaces are occupied successively by *Eragrostis ciliaris*, *Cyperus rotundus* and *Dactyloctenium aegyptium* (small form). This stage may be described as the pioneer stage. The appearance of *Aristida* and *Eragrostis tremula* marks the beginning of the first weed stage. The plants are sparse at first, but gradually dominate the area. Some grazing is available for cattle at this stage. The appearance of *Cynodon dactylon* marks the return of perennial species. *Tephrosia purpurea* is the chief species of the second weed stage; *Cenchrus ciliaris* then appears, eliminates the *Tephrosia* and occupies the area. Finally *Dichanthium annulatum* succeeds *Cenchrus ciliaris*.

The sub-climax in these semi-arid tracts is, therefore, not the present dominant *Cenchrus ciliaris*, but *Dichanthium annulatum*. Observations in the protected area of Agra aerodrome also showed the dominance of *Dichanthium annulatum* over *Cenchrus ciliaris*. Sen (1952) mentions the gradual elimination of *Cenchrus ciliaris* by *Dichanthium annulatum* in the waste land grazing blocks in Agra. From experiments at Nurpur, Mohan (1942) concluded that *Dichanthium annulatum*, *Heteropogon contortus* and *Bothriochloa pertusa* are higher in succession than *Themeda anathera*, *Cenchrus ciliaris* and *Chrysopogon* sp., as the former species replaced the latter following complete closure.

Similarly, in the paddocks at the Karnal sub-station of the Indian Agricultural Research Institute *Cenchrus ciliaris* and *C. setigerus* have replaced *Dichanthium annulatum*, due to continuous grazing. A paddock closed to grazing for two years clearly indicated the agresssiveness of *Dichanthium annulatum* over *Cenchrus ciliaris*. The disappearance of *Dichanthium annulatum* due to grazing

is related to its superior palatability (cf. Burns' remark : "Cattle will sort it out and eat it first"). It, therefore, appears that in the *Cenchrus*-dominant areas regression has proceeded only one step. Regression to the *Cynodon* stage is also frequently found; it appears that *Cynodon* resists the regressive forces very tenaciously, but once this stage is passed, deterioration is rapid.

Observations at Delhi indicate the same successional changes. The invasion of *Saccharum spontaneum* (kans) appears to occur at the *Cynodon* stage; this is also indicated by the fact that *kans* is not found in grasslands dominated by *Cenchrus* or *Dichanthium*. Similarly, on land from the pioneer stage of development onward, *kans* grass is only spasmodic. The eradication of *kans* by the introduction of *Cenchrus ciliaris* or *Dichanthium annulatum* may afford a promising ecological approach.

We are, therefore, inclined to recognise *Dichanthium/Cenchrus* as a major type grassland and, depending upon the degree of regression, to distinguish four sub-types dominated respectively by *Cenchrus, Cynodon, Aristida* and *Dactyloctenium*.

Loamy soils subject to water-logging show a characteristic associated flora. The principal grass species at Ballasar colony in North Gujarat are *Ischaemum rugosum, Iseilema wightii, Desmostachya bipinnata, Dichanthium annulatum* and *Echinochloa colonum*, associated with *Heteropogon contortus, Bothriochloa pertusa, Apluda aristata* and *Andropogon pumilus*. The dominant weed is *Hygrophylla spinosa*. Such areas are found in paddy districts to the north of Ahmedabad The limiting factor in the attainment of an economic grassland type is bad drainage. Efficient drainage causes the following successional changes. The *Hygrophylla* colonies are invaded by the annual *Ischaemum rugosum*, followed by *Desmostachya bipinnata, Iseilema wightii* and finally *Dichanthium annulatum*. Areas north of Delhi on the Delhi-Karnal Road are similar in type. The soil at Karnal is heavy loam and subject to water-logging; the characteristic species are *Desmostachya* and *Dichanthium annulatum*.

Saxton and Sedgwick (1918) describe the ecology of grasslands at Harsol and Modassa in North Gujarat. The soil is darker in colour, and constantly subsides into smal water holes varying from one to ten feet in breadth and one to four feet in depth. "These grasslands are covered with stretches of magnificient fodder grasses," principally *Ischaemum rugosum, Cymbopogon martini, Eremopogon foveolatus, Dichanthium annulatum, Heteropogon contortus, Apluda aristata, Iseilema wightii* and *Themeda triandra*. *Apluda* does

PLATE VII

With increasing soil moisture, *Dichanthium annulatum* is gradually replaced by *Iseilema laxum*. *Dichanthium annulatum* is in the background, while the low lying area in the foreground is completely covered by *Iseilema laxum*

Photo : ICAR Grassland Survey Team.

Increasing intensity of grazing induces erosion. On the resulting stony soils, *Chrysopogon montanus* is dominant, with a scattered stand of *Sehima nervosum* in the less eroded patches

Photo : ICAR Grassland Survey Team

not form colonies freely. *Eremopogon foveolatus* is rather patchy. *Themeda* is not as common as in the areas south of Tapti river. *Dichanthium annulatum* is generally preferred. The authors note that these *'birs'* are generally cut twice, once towards the end of the monsoon and the other in the month of November. The winter cuttings contain mainly *Dichanthium annulatum*, *Ischaemum rugosum* and *Iseilema* which prefer the wetter and more low lying portions of the *'birs'*.

A similar grassland type is found on heavy loam soils to the south of Baroda, in a higher rainfall region (40 to 60 inches). In a detailed study on the Bakrol Cattle Breeding Farm near Baroda, made in connection with the Indian Council of Agricultural Research Pasture Land Scheme, the following floristic composition was observed during 1943. Most of the bulk is contributed by *Dichanthium annulatum*, *Ischaemum rugosum*, *Themeda triandra*, and *Eremopogon foveolatus*. Other important species are *Desmostachya bipinnata*, *Chrysopogon montanus* (robust form), *Iseilema laxum*, *Apluda aristata*, *Heteropogon contortus* and *Andropogon pumilus*.

The following leguminous species are present : *Indigofera hirsuta*, *Crotalaria* sp., *Alysicarpus rugosus* and *Bhynchosia* sp. The dominant tree vegetation is *Butea frondosa* (stunted form) and *Acacia arabica*. In these *Butea* savannahs, *Dichanthium annulatum* represented the economic climax, but *Chrysopogon montanus* is higher in succession, as was indicated by the gradual replacement of *Dichanthium annulatum* owing to the selective cutting to which it is subjected.

The successional changes in this type of grassland appear to be as observed at Ballasar colony. Here perennial tussock-forming species belonging to the Cyperaceae play an important role in the final domination of *Dichanthium annulatum*.

The grassland on these loamy soils is, therefore, characterized by the presence of *Dichanthium annulatum*, but unlike on sandy soils, this is not the last species to occupy the land. It will be seen from the description given under the major *Sehima*/*Dichanthium* type, that the occupation of land by *Dichanthium* represents a stage towards the final domination of the *Sehima* cover ; hence we recognise the *Dichanthium* grasslands on loamy soils as a subtype under the *Sehima*/*Dichanthium* major type. This subtype merges into an *Iseilema* subtype described at Ballasar Colony, when the moisture content increases or the land suffers from water-logging.

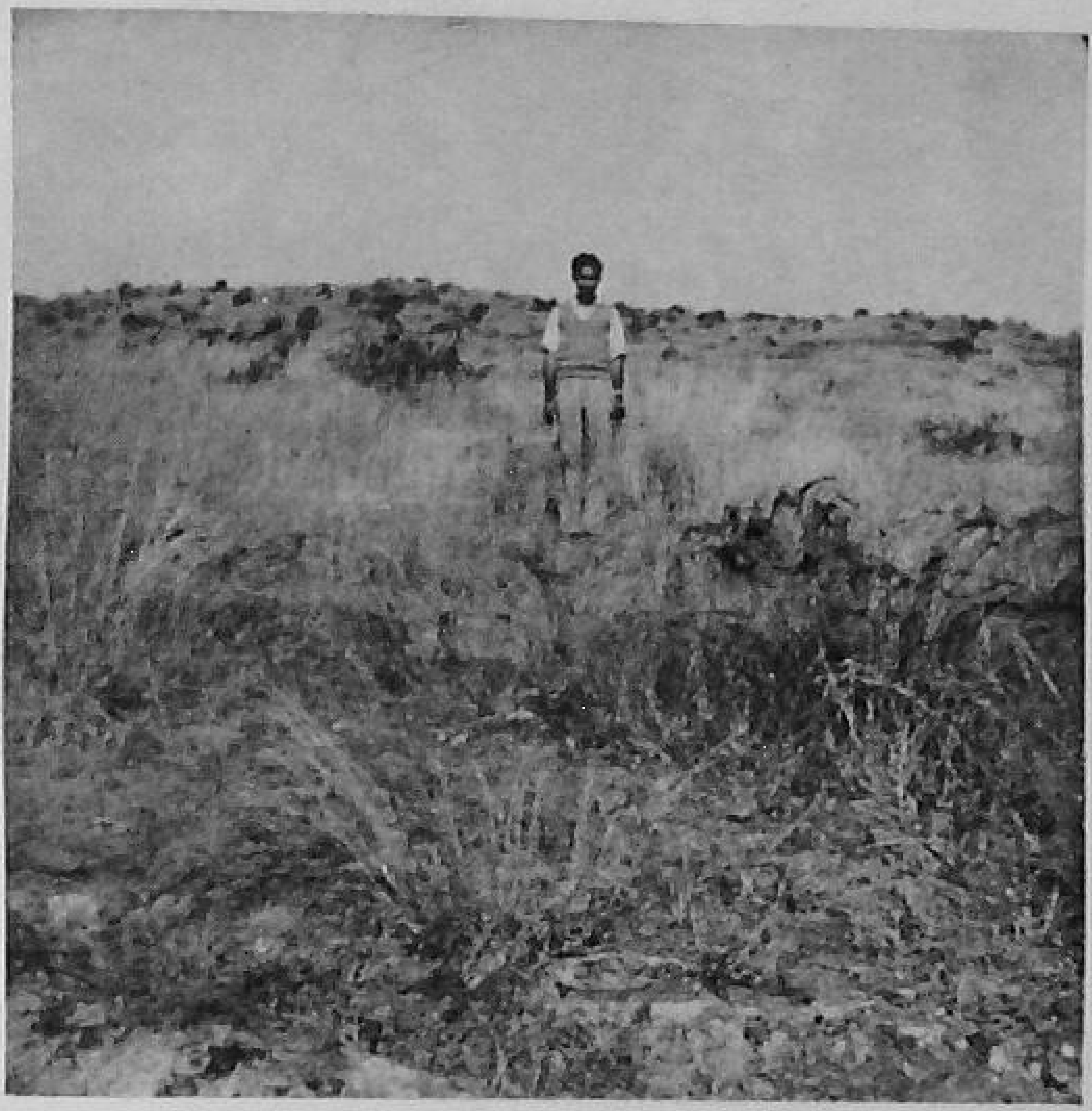
The extensive alkaline areas in this Zone are known as *usar* lands. The soils are sandy to loamy and are highly saline, with chlorides, sulphates and carbonates of sodium predominating. Such areas have a characteristic grass vegetation. A typical *usar* area has been studied at the Dry Experimental Station, Harij, in the north of Mehesana district bounding the Rann of Kutch, in connection with a grass development scheme of the Indian Council of Agricultural Research. The area is dominated by *Prosopis spicigera*. The grasslands occur both as undergrowth and in open patches. The dominant grasses are *Eriochloa ramosa* (21 per cent), *Chloris virgata* (20 per cent), *Eragrostis ciliaris* (20 per cent), and *Dactyloctenium aegyptium* (17 per cent) ; the remainder is composed of *Sporobolus marginatus*, *Dichanthium annulatum* and *Cenchrus ciliari* . Other associated species are *Digitaria adscendens*, *Sporobolus helvolus*. *S. coromandelianus*, *Echinochloa colonum*, *Eleusine compressa*, *E. brevifolia*, *Cynodon dactylon*, and *Aristida* sp. The associated legumes are *Heylandia latibrosa* and *Indigofera* sp. The Cyperaceae are *Cyperus bulbosus*, *C. rotundus* and *Fimbrystylis* sp.

In the same area but adjacent to a small salt-water *nullah*, the dominant vegetation is *Dichanthium annulatum*, *Sporobolus marginatus* and *Eriochloa ramosa*. *Sporobolus marginatus* is observed on pure salt crust. The presence of *Dichanthium annulatum* indicates that the alkaline areas could develop into very good grasslands if protected from grazing. In general, the grass species have a high protein content.

As will be shown in Zone III, the grassland type associated with alkaline areas is a specialized subtype under the *Dichanthium* major type on the sandy soils.

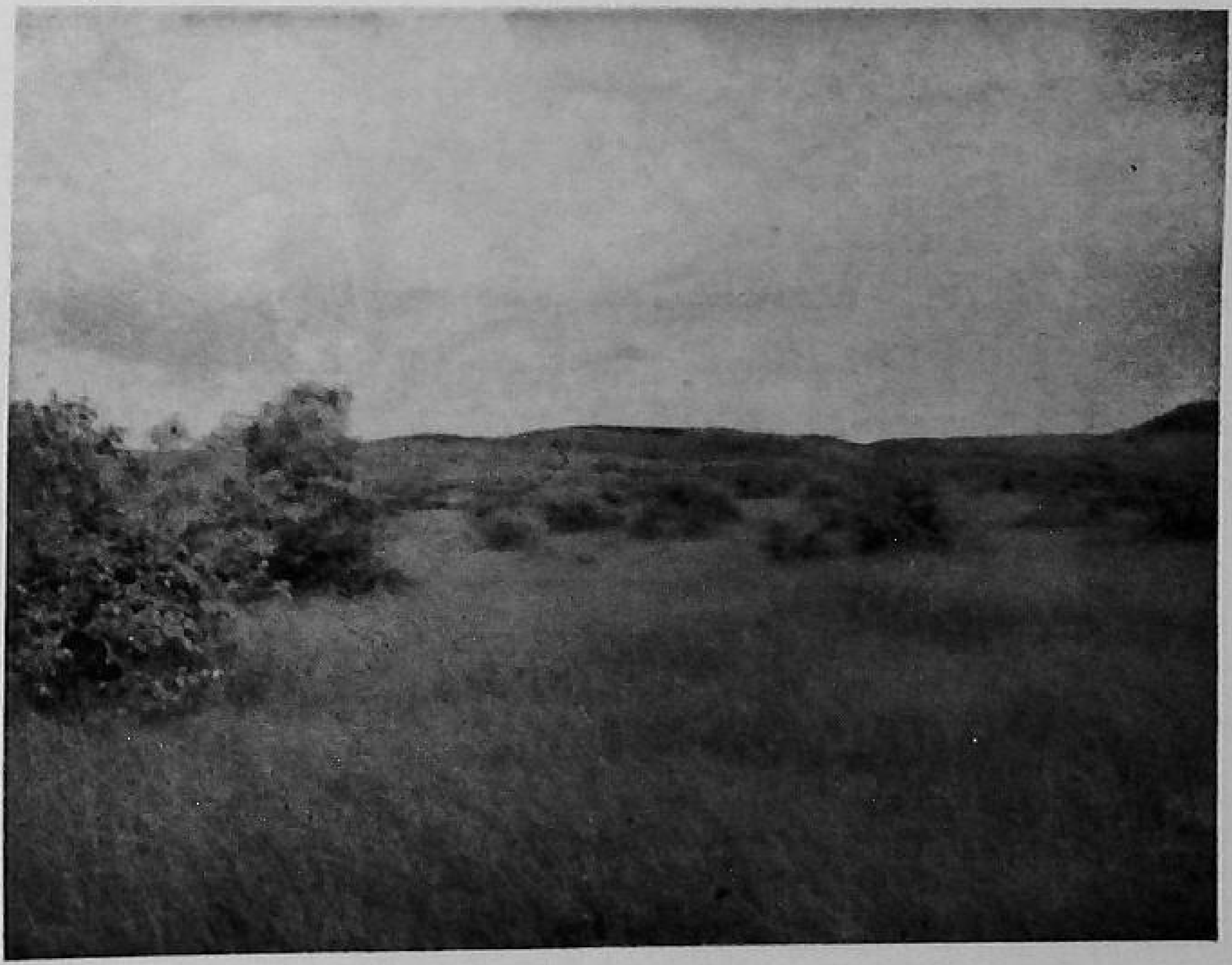
In the alkaline areas of the loam soils at Karnal substation of the Indian Agricultural Research Institute, a more varied type of vegetation may be seen. The dominant grass is *Sporobolus marginatus*. Next in importance are *Desmostachya bipinnata*, *Cynodon dactylon* and *Echinochloa colonum*. Other associated species are *Setaria glauca*, *Eriochloa ramosa*, *Mnesithea laevis*, *Paspalum scrobiculatum*, *Dactyloctenium aegyptium*, *Sporobolus coromandelianus* and *Dichanthium annulatum*. At Karnal and Delhi, *Desmostachya bipinnata* may mark the beginning of the *usar* formation later occupied by *Cynodon dactylon*. *Chloris* species are practically absent. The presence of a mixed association of halophilous vegetation indicates that the soils are at first occupied by the former species and as the salt content increases, they make way for more salt-tolerant

Plate VIII



Still greater intensity of grazing and consequent soil erosion brings the grassland down to the *Hetero-pogon/Eremopogon* stage

Photo : ICAR Grassland Survey Team



The last stage in the regression of the *Sehima/Dichanthium* type is represented by inferior annuals, *Aristida* spp. and *Gracilea royleana* being predominant

Photo : ICAR Grassland Survey Team

species. *Cynodon dactylon* probably represents the link between the two types of vegetation.

Some lateritic soils occur in the southwest of Zone II. Saxton and Sedgwick (1918) describe a typical grass association on the lateritic plateau of Talod in North Gujarat. They note complete absence of larger trees. The dominant tree and shrub species are *Butea frondosa* (stunted form), *Acacia arabica*, *A. leucophloea*, *Dichrostachys cinerea*, *Capparis aphylla* and *Zizyphus rotundifolia*. The grass flora is represented by species of *Digitaria*, *Hackelochloa granularis*, *Heteropogon contortus* (small form), *Sehima nervosum*, *Aristida funiculata*, *Eragrostella bifaria* and *Eragrostis pilosa*. The legume associates are *Rhynchosia minima*, *Crotalaria linifolia*, *Alysicarpus*, *Indigofera triata* and *I. glandulosa*. In the Vindhya and Satpura Ranges, which represent the continuation of Talod area, *Sehima nervosum*, *Themeda* and *Cymbopogon* occur. This association is discussed more fully under Zone IV, and falls under the *Cymbopogon* major type.

In the southeast portion of the zone, comprising Madhya Bharat, the characteristic species of the grasslands on the black cotton soil are *Sehima sulcatum*, *S. nervosum*, *Ischaemum pilosum*, *Chrysopogon montanus*, *Dichanthium annulatum* and *Heteropogon contortus*. The first two grow on well-drained black cotton to sandy loam soils with a rainfall between 30 to 40 inches. The association cannot stand water-logging or heavy rainfall. It is similar to that described as the *Sehima* major type in Zone IV, and possibly extends to Bhopal and the southwestern part of Uttar Pradesh.

The *Heteropogon* subtype described in more detail in Zone I and IV is also fairly well represented in the Zone, both in the hills and the plains on black soils where annual burning is practised.

There are vast areas in Bhopal and Madhya Bharat where the cultivated fields are dominated by *Saccharum spontaneum* (*kans*), which represents an extremely difficult problem for the agriculturist. As already stated, the invasion of *kans* appears to take place at the *Cynodon* stage, distinctly lower in ecological level than *Dichanthium* and *Cenchrus;* it does not, therefore, represent the climax species and may be considered only as a short intermediate phase between *Cynodon* on the one hand and *Dichanthium* on the other. This contention is further strengthened by observations of the cultivators that *kans* would 'oust itself' in about eight to ten years after being dominant in a field.

Grassland Types in Agricultural Zone III

Zone III comprises a portion of Uttar Pradesh east of Lucknow; the whole of Bihar, Orissa, Bengal, Assam, the eastern part of Madhya Pradesh and Hyderabad State and the northern parts of Madras State consisting of Ganjam, Vizagapatam, Godavari and Krishna districts. Except for the Chhota Nagpur plateau, the eastern extremity of the Satpura Range in Madhya Pradesh, and the maze of mountains in Assam represented by the Jaintia. Khasi and Garo Hills, the whole region constitutes the eastern portion of the great low land plain of the Middle Ganges and Brahmaputra valleys and the deltas formed by the Ganges, Godavari and Krishna and Mahanadi rivers. The rainfall in general varies from 40 inches in the western part and 70 inches in the middle to over 80 inches in Assam, with Cherrapunji receiving the highest rainfall in the world (425 inches). The soils are generally alluvial, although lateritic soils are quite frequent.

The swampy areas such as the Sunderbans are characterized by low forest, interspersed with patches covered with tall grasses. The grass association is similar to the *Phragmites / Saccharum* type described in the Terai region of Zone I. The main grass species in the association are *Phragmites karka*, *Saccharum spontaneum*, *Imperata cylindrica* and *Bothriochloa intermedia*. This type is fairly well represented along the Brahmaputra river, e. g. in the Kaziranga Game Sanctuary in the plains of Assam, and also in the moist localities in Chhota Nagpur.

The grass flora on the fresh alluvium is distinct, and probably represents a first step towards the formation of the above major type. In order of frequency, the grass species are ; *Oryza coarctata*, *Zoysia pungens*, *Sporobolus tremulus*, *Myriostachya wightiana*, *Panicum repens* and *Paspalum distichum*. This association may, therefore, be recognized as the *Oryza/Zoysia* subtype within the *Phragmites/Saccharum* major type. The subtype extends into the rice plains of West Bengal, especially along the river banks (Prain, 1903).

The grass association common in the alluvial soils of the plains is composed of *Ischaemum aristatum*, *I. rugosum*, *I. semisagittatum*, *Themeda quadrivalvis*, *T. triandra*, *Dichanthium annulatum* and *D. caricosum*. This association resembles the association described on loamy soils in Zone II. The presence of *Ischaemum* is characteristic of the low-lying areas in Zones II and III, and defines the *Ischaemum* subtype under the major *Dichanthium* type. This

association occurs in the paddy tracts of Assam from Gauhati to Cherrapunji, in the plains of Bengal and the paddy tract of Madhya Pradesh, and is probably distributed throughout the Zone.

Prain (1908) describes the typical vegetation of the roadsides and waste places in the districts of Hughli, Howrah and in twenty-four Parganas which possibly extend into South Bihar and the western part of West Bengal. The grass association consists of *Panicum psilopodium, Digitaria pedicellaris, Tragus racemosus, Schizachyrium brevifolium, Bothriochloa pertusa, Iseilema laxum, Aristida adscensionis, Polypogon monspeliensis, Arundinella wallichii, Eragrostis coarctata* and *Chloris virgata*. The association is similar to that described by Saxton and Sedgwick (1918) on the laterite plateau of Talod in North Gujarat, referred to under Zone II. The preponderance of annual over perennial species like *Bothriochloa pertusa* suggests that this association is a degraded form of some higher type. The domination of *B. pertusa* in the open grasslands of Jashpur and Surgiya recorded by Mooney (1950) further suggests that the association recorded by Prain is lower in type. *B. pertusa* again appears to be only an intermediate phase below the *Cymbopogon* type found in the hilly areas north of Poona in Zone IV, and along the Vindhya ranges in Zone II.

The *Heteropogon* subtype which arises following periodic burning is well-represented in this Zone, e. g. in the *sal* forest of Bihar and Orissa, and in the tropical dry deciduous forest in Northeast Madhya Pradesh (Misra and Joshi, 1952).

The grassland vegetation on hill slopes in Saugar (Pandeya, 1952) consists mainly of *Aristida redacta, A. cyanantha, Bothriochloa pertusa, Heteropogon contortus, Themeda caudata, Cymbopogon martini, Apluda aristata, Sehima nervosum, Dichanthium annulatum* and *Iseilema anthephoroides*.

Species on level ground are *Chloris virgata, Bothriochloa pertusa, Iseilema anthephoroides, Heteropogon contortus* and *Sehima nervosum*, with the legumes *Heylandia latibrosa, Indigofera linifolia* and *I. cordifolia*.

The association reminds one of the *Cymbopogon* type with its subtypes described in detail under Zone IV.

Larger tracts around Cherrapunji in Assam exhibit a distinct major type within the tropical wet evergreen forest. Owing to excessive felling, the hills

are now covered with grasses and are more or less stable under a system of heavy grazing and annual burning. The type is dominated by four or five species belonging to the genus *Arundinella*. *Chrysopogon montanus* is rare. A similar association is observed in the Nongpoh and Nowgong area, where again evergreen tree forest has been cleared. Legumes are represented by four or five species of *Desmodium*. Because of the almost complete dominance of *Arundinella* in these grasslands, they may be recognized as a major *Arundinella* type. The description of the types in Zone I shows that the *Arundinella* type is fairly well represented at high altitudes.

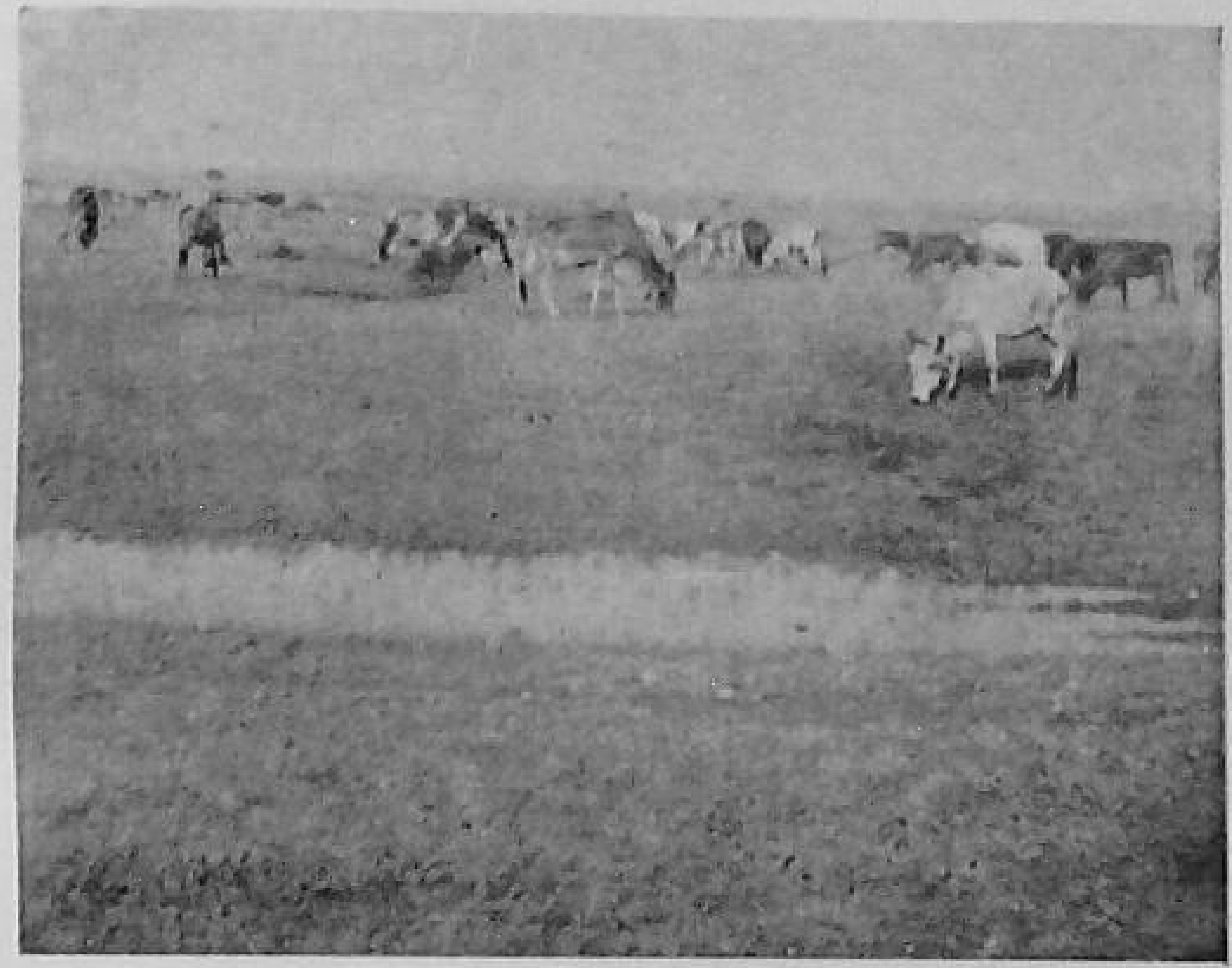
Common grasses on exposed rocks around Cherrapunji are *Pogonantherum*, *Garnotia* and *Chrysopogon montanus*. This type probably represents the extreme stage of degradation under heavy grazing and annual burning, promoted by heavy rainfall.

The Nongpoh tract represents a combination of the deciduous and evergreen forest climax. Common grasses associated with the forests are *Microstegium ciliatum*, *Oplismenus*, *Capillipedium*, *Panicum* spp. and *Eragrostis*. *Thysanolaena*, *Erianthus* and *Themeda villosa* are observed on exposed slopes.

Alkaline soils : On the alkaline soils in Uttar Pradesh, the typica grass flora resembles that already described for Zone II. Asthana (1944) studied the vegetation of *usar* and *reh* soils near Lucknow. *Sporobolus marginatus* and *Chloris montana* are dominant, depending upon whether the land is protected or grazed. A third closely associated species is *Dactyloctenium aegyptium*. Other grasses in these associations are : *Sporobolus helvolus*, *S. coromandelianus*, *Chloris virgata*, *Setaria glauca* and *Paspalidium flavidum*. Because species of *Sporobolus* and *Chloris* are dominant and invariably associated with these alkaline areas, this grassland type may be recognised as the *Sporobolus* / *Chloris* subtype. *Sporobolus marginatus* has a greater capacity to dominate *Chloris montana* and other species when protected from grazing and cutting. Under grazing conditions, *Chloris montana* becomes dominant. *Chloris*/*Dactyloctenium* may, therefore, be recognised as a subtype.

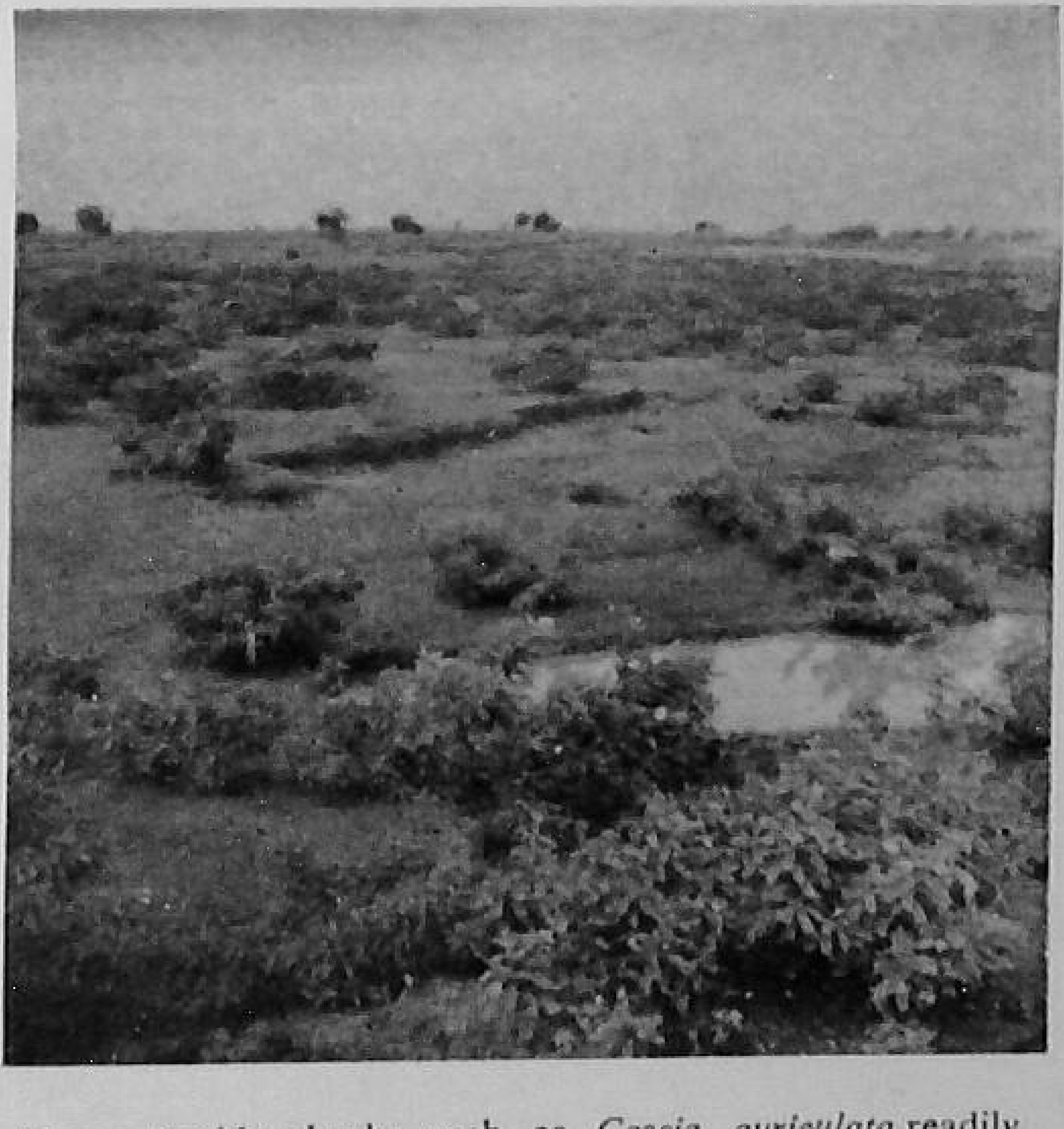
With the removal of the biotic factor, *Sporobolus marginatus* gradually covers the area. The extensive foliage gives a thicker soil cover and helps to minimize the upward capillary movements of the salts. It thus prepares the way for other grasses, such as *Cynodon dactylon*, *Iseilema laxum* and *Dichanthium annulatum*, which can take advantage of the improved condition of the soil. A

PLATE IX



A typical overgrazed area still subject to continued heavy grazing

Photo : ICAR Grassland Survey Team



Non-palatable shrubs such as *Cassia auriculata* readily encroach in overgrazed grasslands. This species is commonly found dominant in overgrazed areas in Saurashtra, North Gujerat, Andhra and Bihar

Photo : ICAR Grassland Survey Team

similar trend is noted at Makhdoompur in Uttar Pradesh ; Kanjilal (1945) recorded the presence of *Cenchrus ciliaris* as well.

This association closely resembles the type described at Harij in Zone II. The ultimate occupation of land by *Dichanthium annulatum* under favourable conditions indicates that on the alkaline areas the *Sporobolus/Chloris* type is only a specialised type depending upon soil conditions under the major *Dichanthium* grassland type.

Grassland Types in Agricultural Zone IV

Zone IV corresponds in general with Peninsular India, south of the Satpura Ranges and embracing the western half of Madhya Pradesh with Berar ; the whole of the Hyderabad State except the small eastern-most part ; the whole of Bombay State, the Deccan (Bellary, Kurnool, Anantpur, Cadapah and part of Chittoor) and southern districts of Madras State lying between the two coasts. Topographically, the whole region is more than 500 feet above sea level and the greater part in the south is over 2,000 feet. The greatest heights are reached on the southern borders, at Anaimalai in Travancore (9,000 feet) and Doddabetta in the Nilgiris (8,760 feet). The lower ground is occupied by the river valleys of Krishna and Penner in the south and Purna, Tapti and Wardha in the north. Except along the Western Ghats the rainfall is less than 40 inches, and in some parts is even below 20 inches. The region may be divided in two on a soil basis. The northern area, corresponding with the northwestern Deccan of Stamp (1939), is characterized by the well-known black cotton soil as far north as the Satpura line and westwards to the crest of the Western Ghats, and embraces all that part of Bombay State on the plateau except Dharwar, with the western half of Madhya Pradesh and Hyderabad State. The southern portion, comprising the remainder of the peninsula, has red soils. The natural vegetation is usually scrub forest, tree forests occurring only in favoured localities. Agriculturally, this is the region of typical dry crops such as millets.

The grass association characteristic of the open grasslands on the black cotton soils, such as occur in Berar, consists of *Sehima sulcatum*, *S. nervosum*, *Chrysopogon montanus*, *Dichanthium annulatum*, *D. caricosum*, *Themeda quadrivalvis*, *Ischaemum rugosum*, *Eulalia trispicata*, *Bothriochloa pertusa*, *Iseilema laxum* and *Heteropogon contortus*. The association has a close affinity to that described on black cotton soils in Zone II, apart from the *Sehima* spp. *Dichanthium annulatum*,

The *Cenchrus* subtype described in Zone II is well-represented in the Coimbatore district of Madras State, where it is the mainstay of the Kangayam breed of cattle. Stray plants of this species are also found in Tinneyvelley, Trichinopoly and other districts (Jacob, 1945).

The grasslands on the hilly areas of this Zone consist principally of *Cymbopogon martini, Themeda quadrivalvis, Th. triandra, Pseudanthistiria hispida, Heteropogon contortus, Ischaemum aristatum, Sehima nervosum* and *Apluda aristata.* The following subtypes are found :

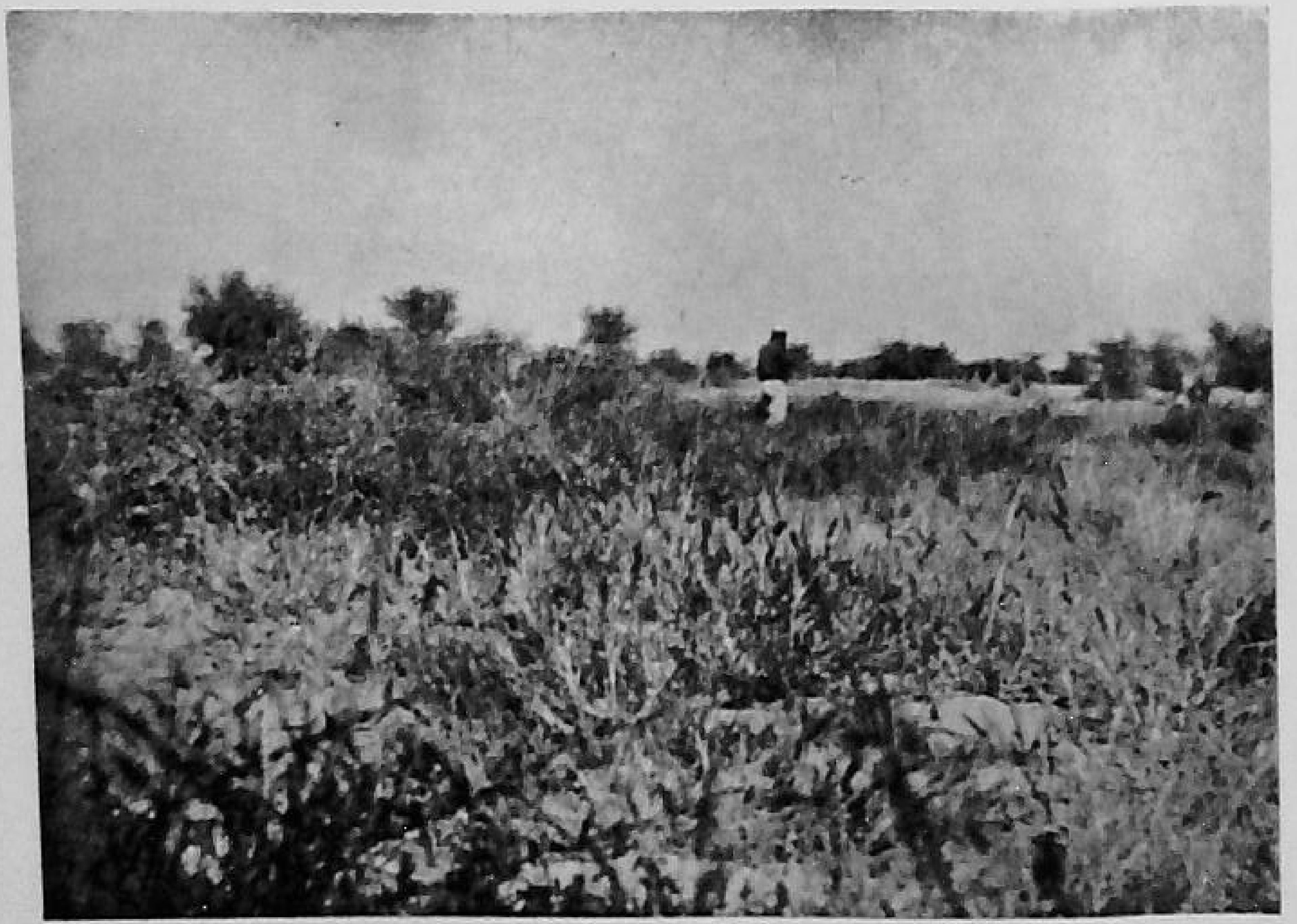
Cymbopogon : The dominant grass is *Cymbopogon martini* with a scattered stand of *Apluda,* especially under bushes. *Cymbopogon* frequently occupies large areas of open grassland, to the exclusion of all other species (Blatter and McCann, 1935). The type has poor grazing value. It is fairly well represented in Bombay State along the Western Ghats, in the Betul and Nimar districts of Madhya Pradesh, in the Melghat Range in Berar, and probably also throughout the Vindhya and Satpura Ranges.

Themeda: *Themeda triandra* and *Th. quadrivalvis* are the principal species. *Themeda triandra* sometimes covers large tracts of land to the exclusion of almost every other plant (Blatter and McCann). The species are sub-gregarious to gregarious in growth and give a characteristic appearance to the hilly slopes. The type is considered as of medium economic value. The distribution is as in the above type.

Heteropogon : Large tracts are covered by this grass, especially where the land has been subject to annual fires. The principal species is *Heteropogon contortus,* possibly the annual form, confined more to open hilly slopes. The subtype is widely distributed throughout the Zone in both the hills and plains. In the plains, the perennial form may predominate. The Belgaum, Bijapur and Dharwar districts of Bombay State and most of the districts in Madras State contain this subtype.

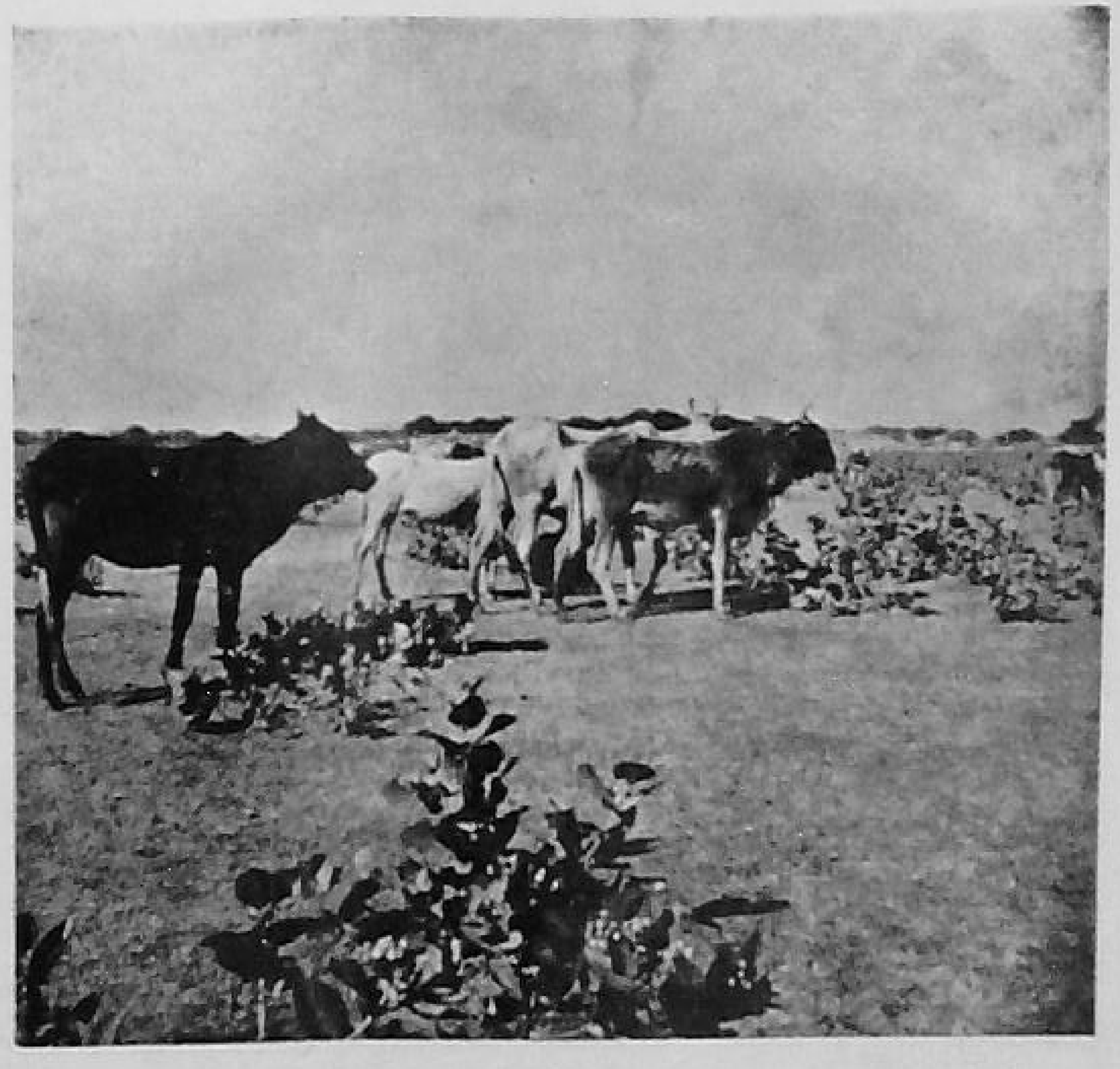
Pseudanthistiria: This consists primarily of dwarf grasses, especially *Pseudanthistiria hispida* with *Ischaemum aristatum* as co-dominant. It covers extensive areas in the Western Ghats around Lonavala, and may also be represented in the Palghar area of Bombay State. The species have been recorded by Blatter and McCann and Roxburgh as appearing on new pasture grounds. The type may be a stage in succession towards the establishment of a *Themeda* type.

PLATE X



An overgrazed area in Mathura, Uttar Pradesh, is being progressively brought up to the *Cenchrus* stage within the *Dichanthium/Cenchrus* type by simple protection for about 3 years. *Cenchrus* spp. represent 38 per cent of the total stand, *Dichanthium annulatum* 10 per cent

Photo : ICAR Grassland Survey Team



Continued overgrazing brings *Dichanthium/Cenchrus* type down to a weak sparse stand of *Sporobolus* and *Aristida*. The non-palatable shrub, *Calatropis procera*, has started to invade this grassland.

Photo : ICAR Grassland Survey Team

Based on the studies of Burns and his associates, Garland (1932) summarized the nature of succession in the grasslands of this tract. It was noted above that at the *Aristida* stage succession follows two distinct lines. The progress in the plains has already been stated. On the hills, *Heteropogon contortus* next assumes dominance, replacing *Aristida*. The sub-dominants *Chrysopogon montanus*, *Bothriochloa pertusa* and *Apluda aristata* gradually become co-dominant, with a scattered stand of *Sehima nervosum* and *S. sulcatum*. As conditions become more favourable for tree growth, *Themeda quadrivalvis* appears and gradually replaces *Heteropogon* until it becomes strongly dominant. Thus, according to Garland, the final stage in the grassland succession is represented by *Themeda*. We consider, however, that *Themeda* represents a transition stage towards the establishment of the sub-climax stand of *Cymbopogon*, and so ultimately to the dominance of tree species.

We, therefore, recognize the *Cymbopogon* type as the major type of grassland in which *Themeda*, *Heteropogon*, *Pseudanthistiria* and *Aristida* are subtypes.

The grassland association in the Nilgiri plateau described by Ranganathan (1938) consists of *Bothriochloa pertusa*, *Ischaemum pilosum*, *Themeda triandra*, *Cymbopogon polyneuros* and *Eragrostis nigra*. The presence of *Themeda triandra* and *Cymbopogon* species in the grasslands suggests that again we have the *Cymbopogon* association as the major type, along with other degraded types. The ecology of the Nilgiri grasslands has been an interesting subject for discussion. As already stated, Ranganathan considers that these grasslands constitute a climatic climax and exist together with the evergreen Shola as the other climatic climax. Bor (1938), on the other hand, maintains that it is merely a biotic climax existing under the influence of fire and grazing.

Fyson (1915) mentions the presence of the temperate grasses, *Bromus asper* and *Brachypodium sylvaticum*, above 6,500 feet on the Nilgiris. Fisher (1921), surveying the flora of the Anaimalai Hills in the Coimbatore district of Madras, divides the grassland type into two subtypes according to elevation. The lower grassland type (below 6,000 feet) consists of *Ischaemum aristatum* and *Cymbopogon nardus* and is, therefore, similar to the *Pseudanthistiria* subtype described earlier.

Grassland Types in Agricultural Zone V

This Zone is the coastal region round the Deccan plateau ; it covers a narrow coastal plain and the slopes of the Western Ghats, and may be divided into

northern and southern parts, lying in the States of Bombay and Madras respectively. The whole region is very wet, but the dry season becomes progressively longer as one goes northwards, away from the almost Equatorial climatic conditions of Travancore State. Apart from the areas north of Bombay, the rainfall exceeds 80 inches.

The East Coast south of the Karnatic region comprises a broad coastal plain and an inland hilly part, and differs from the rest of India in the incidence of rainfall. The coastal plain receives about 40 inches per annum, falling mainly in October, November and December. The hilly western parts have less than 40 inches, and the regime is nearer the normal.

The grassland association in the northern half of the West Coast is represented by *Themeda triandra*, *Pseudanthistiria heteroclita*, *Ischaemum aristatum*, *Eulalia fimbriata* and *Eragrostis unioloides*. The association is, therefore, similar to the *Cymbopogon* type described in Zone IV. Bharucha and Dave (1952) have shown that the grassland formation occurs in the fourth stage of regression from the *Tectona*/*Terminalia* type of tropical moist deciduous forest. The factors bringing about these changes are cutting of trees and fires. The introduction of the grazing factor brings about further regressive changes through the gradual disappearance of *Themeda* and *Pseudanthistiria* and their replacement by *Eulalia*. The appearance of *Eragrostis unioloides* introduces the downward succession to the bare rock formation. The *Eragrostis unioloides* stage perhaps corresponds to the pioneer type represented by *Oropetium*, *Melanocenchris* and *Tripogon* in Zone IV. Enclosure at the *Eragrostis* stage accelerates the upgrade succession until in three years time the *Themeda* stage is reached. Manuring at the *Pseudanthistiria* stage produces a favourable response, which is not obtained when done at the *Eragrostis* stage. This association perhaps applies to the whole coastal region of Bombay State.

The hilly areas in the southern half of the coastal region have an association consisting of *Themeda tremula*, *Th. triandra*, *Heteropogon contortus*, *Ischaemum aristatum*, *Arundinella mesophylla*, *A. fuscata*, *A. setosa*, *Tripogon bromoides*, *Chrysopogon zeylanicus*, *Eulalia phaeothrix*, *E. trispicata*, *Bothriochloa insculpta* and *Cymbopogon flexuosus*. The association found in Travancore resembles, in general, the *Cymbopogon* type of the Western Ghats, of which the hill ranges in Travancore are a continuation. Depending upon grazing and annual fires, different subtypes are found, with *Themeda* and *Heteropogon* subtypes common. The

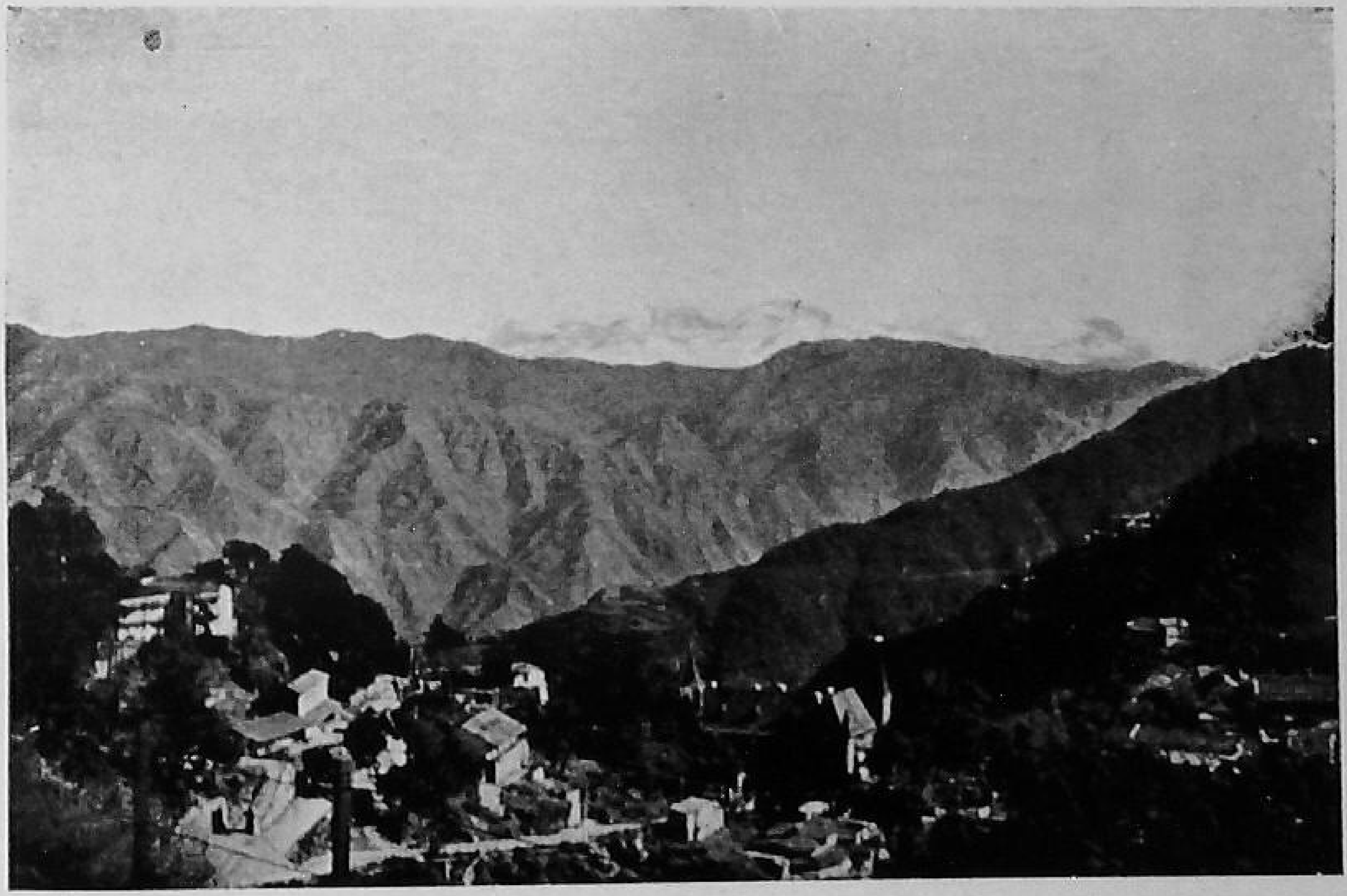
Plate XI

A general view of grassland at Cherrapunji, Assam. The main grasses are species of *Arundinella*, *Chrysopogon*, *Dimeria* and *Ischaemum*.

Photo : ICAR Grassland Survey Team

Typical grassland at high altitude in Kashmir, probably representing one of the stages in the *Deyeuxia/Deschampsia* type.

Photo : ICAR Grassland Survey Team



Deforested mountains typical of much of the lower parts of the Himalayan range, seen from Mussoorie, Uttar Pradesh. The loss of water conserving capacity is responsible for much of the flooding caused by the rivers issuing into the Gangetic Plain

Photo : R. O. Whyte

Pseudanthistiria stage is probably represented on heavily grazed areas by *Ischaemum aristatum*.

The occurrence of *Arundinella, Tripogon bromoides, Chrysopogon zeylanicus* and *Eulalia* species indicates the *Arundinella* type described in Zones I and III, which appear to be characteristic of the high mountains in southern India. The demarcation line between these two major types, namely *Cymbopogon* and *Arundinella*, appears to be roughly between 3,000 to 4,000 feet, the former occurring below this, the latter above this line.

In the plains between the mountain ranges and the sea coast characterized by sandy alluvial soils, a *Dichanthium* type appears to prevail. The marshy areas in the coastal region probably represent the *Phragmites* type described in Zones I and III, with *Zoysia* and *Panicum repens* as the pioneer species.

In the East Coast or Karnatic region, the *Heteropogon* subtype appears to be dominant under the *Cymbopogon* type described in Zone IV.

TABLE XVIII

Progressive and regressive stages of succession in some of the major grassland types

(This outline has been prepared on the basis of the first two years' work of the I. C. A. R. Grassland Survey. It does not, therefore, agree in all respects with the foregoing text, written at an earlier date.)

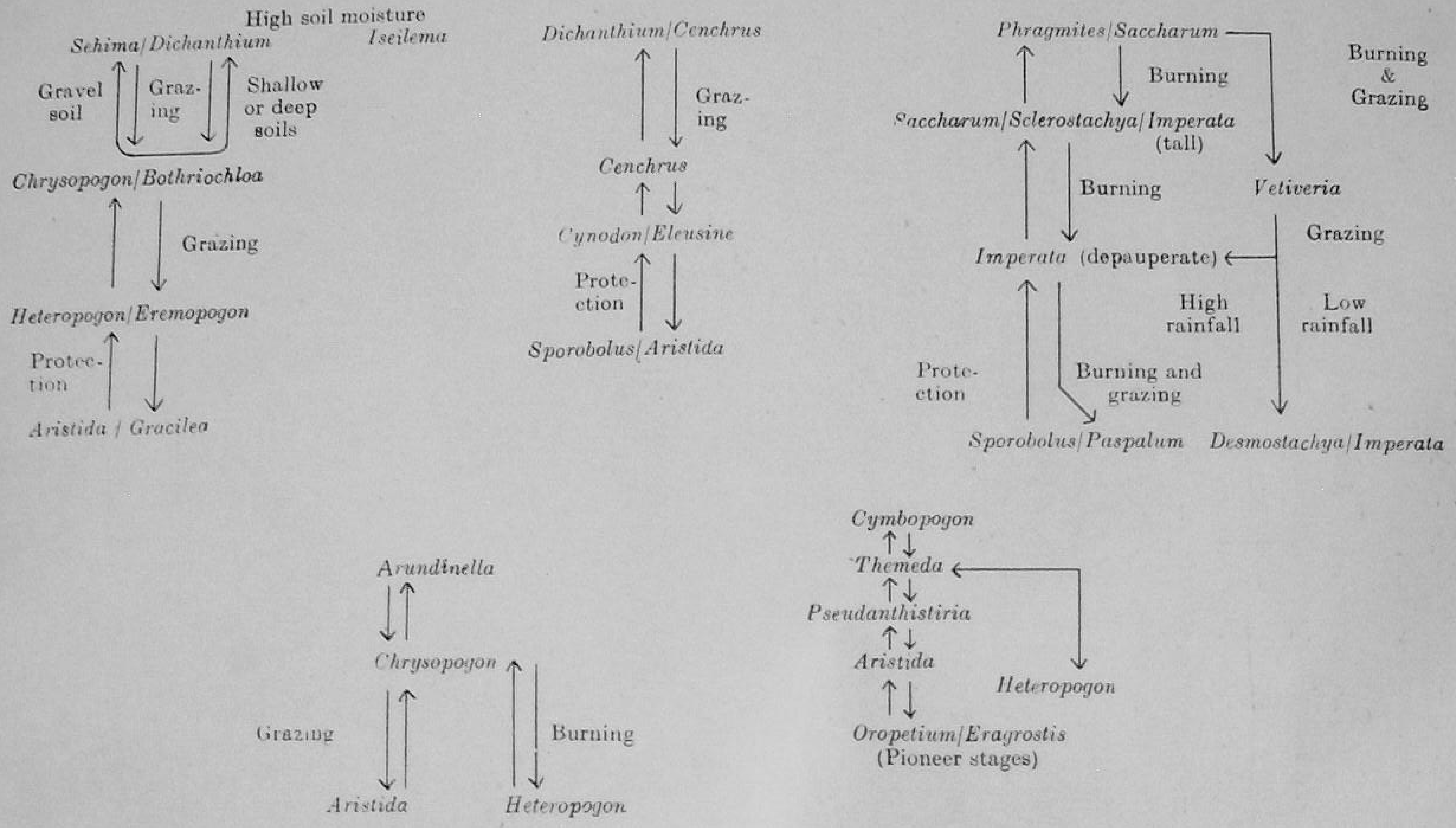


TABLE XIX

Distribution of the major grassland types in India

Sehima / Dichanthium	Western Hyderabad, Bombay, Western Madhya Pradesh, Madhya Bharat, Bhopal, South-west Uttar Pradesh, Western Andhra, Mysore, Madras
Dichanthium/Cenchrus	Plains of Punjab, P. E. P. S. U., Delhi, Rajasthan, Eastern Uttar Pradesh, Saurashtra, Kutch, North Gujerat, Bengal, Bihar, Orissa, North Andhra, Eastern Madhya Pradesh, E astern Hyderabad, Travancore-Cochin, West Coast of Bombay, Eastern Madras
Phragmites/Saccharum	Terai areas of Uttar Pradesh, Bihar, Bengal and Assam, swamps of Sunderban, Kaveri delta of Madras
Bothriochloa	Lonavala tract of Bombay
Cymbopogon	Low hills of Western Ghats, Western Ghats, Vindhya, Satpura, Aravali, Chhota Nagpur Plateau up to 3,000 feet
Arundinella	High hills of Western Ghats, Nilgiris, lower Himalayan region in East Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, Bengal and Assam, up to 6,500 feet
Deyeuxia/Arundinella	Upper Himalayan region in East Punjab, Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, Bengal, Assam
Deschampsia/Deyeuxia	Alpine and sub-alpine regions of the main Himalayas in Kashmir, East Punjab, Himachal Pradesh, Uttar Pradesh, Bengal, Assam over 6,500 feet

CHAPTER VII

FODDERS, FEEDS AND CONCENTRATES

IN any properly designed grazing and fodder calendar, there must be a correct balance between all the sources of animal feed which are available to maintain the livestock on an adequate plane of nutrition throughout the year. Under ideal conditions and particularly with high-producing dairy stock, the amount of protein, carbohydrate and other nutrients should remain uniform as far as possible month by month. With certain types of livestock and in most types of animal husbandry in India, the calendar departs to a greater or less degree from this ideal.

The nature of the seasons and the character of the natural vegetation together govern the type of pasture and fodder calendar which can be adopted. In favoured grassy countries like Great Britain or New Zealand, even high-producing dairy stock can be maintained on natural pastures or their conserved produce in the form of hay and silage during most of the year, plus the concentrates necessary for high production. Because of the nature of the seasons and of the natural vegetation in India, grazing can provide a much smaller proportion of the total nutrients in both quantity and quality. The optimal grazing season does not extend for more than four to five months of the year. In addition, the quality of the natural herbage, and particularly its protein content are not sufficient to provide a full maintenance ration for quality livestock. In Chapter VIII it will be noted that carefully planned fodder calendars make little allowance for grazing on natural grassland. The better the animal, the less can it obtain food of any great value from natural grazings.

In other conditions, the policy of the fodder agronomist would be to produce artificial pastures incorporating legumes as the source of protein. There is as yet no good evidence to show that artificial pasture can be established on any great scale in India, nor that legumes can be incorporated either in natural grasslands or artificial mixtures. In addition, there is no Indian equivalent to white clover, which actually thrives under conditions of heavy grazing.

For these reasons, therefore, it is necessary in India to exploit every other source of animal fodder and particularly any feeds of high-protein value which

PLATE XII

Ficus palmata, common on dry slopes up to 9,000 feet in Kulu and the Simla hills, frequently lopped for fodder. Palmata-leaved form on left and ordinary form on right.—Punjab

Photo : T. V. Dent

may not only supplement the maintenance ration, but also leave something for production. The first obvious problem to consider is the production of leguminous and other fodders from arable land.

Fodder crops

The very great discrepancy between demand and supply as far as fodder is concerned is shown in other chapters. Table IV for example, shows that there are 16 cattle per acre of cultivated fodder crop over the whole of India, and that there are great variations in this respect between different regions of India. Any increase in this acreage would have to be very considerable if it were to meet not only the great deficiency in protein and carbohydrate (expressed by Kehar, 1953), but also to provide nutritive fodder to supplement grazing during the grazing months and replace it entirely for the greater part of the year. It would, of course, be desirable to replace much of the basic fodder of India, cereal straws, by good hay or superior fodders, but that is hardly a feasible proposition under present circumstances.

The Joint Committee of the Indian Council of Medical Research and the Indian Council of Agricultural Research (Government of India, 1952) estimates that the area required for growing feeding stuffs for the different classes of livestock (work producers, milk producers and followers) is 78 million acres (irrigated fodder 11.5, dry land fodder 8.0, maize 28.5 and gram 30.0).

The Committee considers that the choice of green fodder may have to be decided according to region and climate. Seasonal excesses should be conserved as silage to replace green fodder during the off-season. Maize is selected because it is rich in energy-producing nutrient, gives a high yield per acre, can be grown in almost all parts of the country, and provides good quality *kadbi*. Gram has been selected as the leguminous seed crop as it is rich in nutrients, palatable to all classes of livestock, and is a staple crop of long standing in the country. *Guar* and cowpea may profitably be substituted whenever possible as they yield not only seeds equivalent in quality to gram but also provide a valuable hay.

Sen (1952) states that in countries where animal husbandry has made great progress a sound diet for cattle is built around a good quality green forage. A properly selected green fodder is well-known to be the most natural food for the herbivores, not only for the balanced distribution of its nutrient constituents but also for its bulk which is necessary to fill the capacious stomach of a ruminant. Moreover, such a combination in a single item of feed has been

found to reduce greatly the cost of feeding, especially for milk production. In India, owing to climatic conditions and other limitations, the possibility of developing organized pasturage will be difficult to realize, but by some reorientation of cropping programmes, if about 10 per cent of the total arable acreage of the country could gradually be appropriated for organized production of fodder crops, the problem of feeding the milk producing animals can, according to Sen, easily be solved.

From these general considerations and calculations on an all-India basis, let us turn to a statement of the position in representative States, the Punjab, Uttar Pradesh and Madras.

Fodder production in Punjab

Improved systems of feeding livestock and an example of a pasture and fodder calendar in the Punjab are given in Chapter VIII.

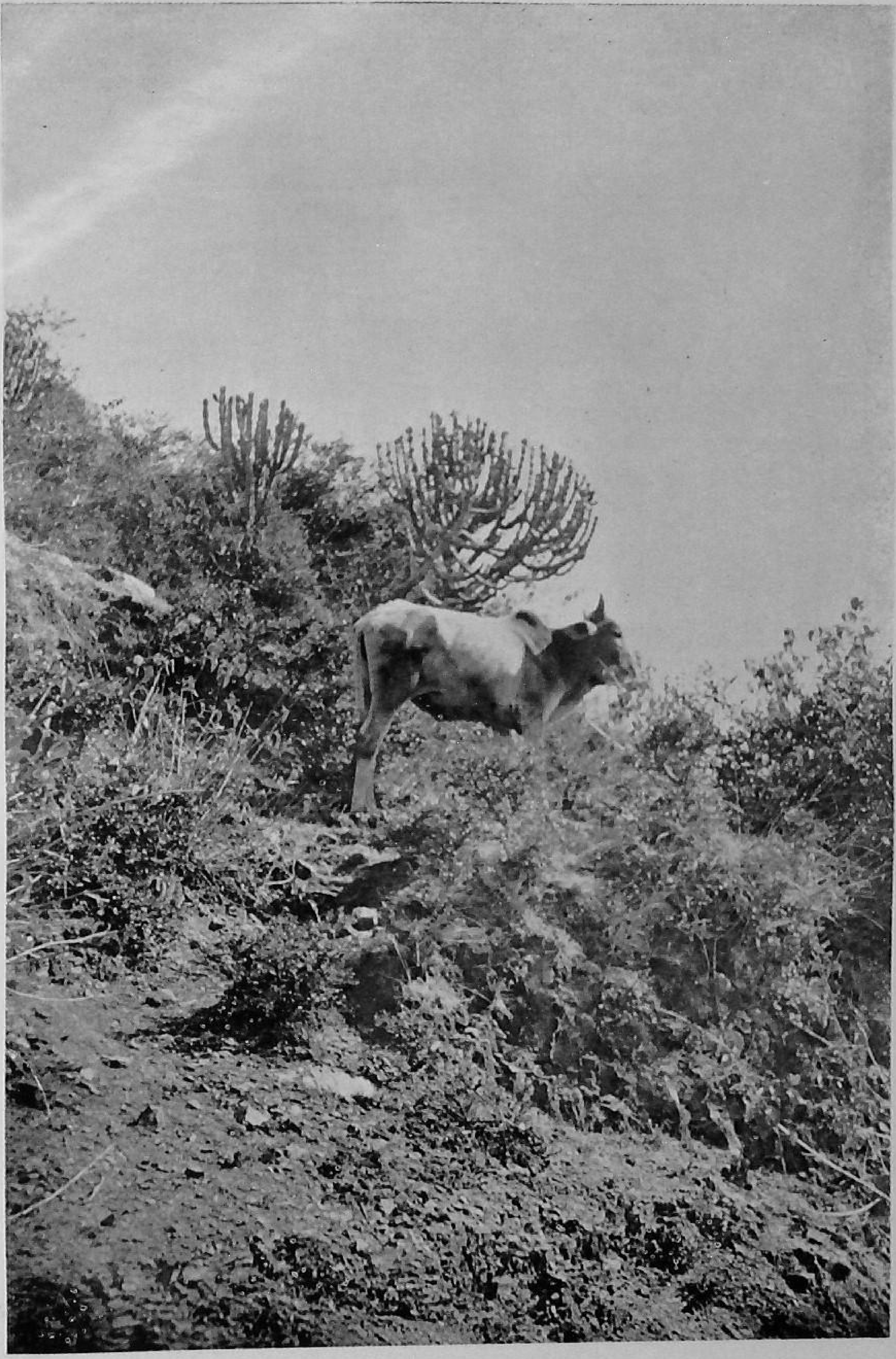
Cereals and pulses constitute about 78 per cent of the sown acreage in this State; figures may vary slightly where increased attention is given to commercial crops like sugarcane and cotton. In the mountain districts of Simla and Kangra, the cereals and pulses occupy as much as 90 and 94 per cent of the total crop area respectively. In the southeastern districts of Hissar, Rohtak and Gurgaon, the figures are 80 and 90 per cent, in the three central districts of Amritsar, Jullundur and Ludhiana, where irrigation facilities are better, food grains occupy only 58 and 66 per cent of the crop area.

Table XX

Legumes grown for grain in 1949/50

Crop	Acreage		
	Irrigated	*Non-irrigated*	*Total*
Gram	6,82,622	23,34,255	30,16,877
Mung	10,925	50,136	61,061
Mash	30,439	1,37,342	1,67,781
Massar	28.362	27,055	55,417
Fieldpeas	5,382	6,724	12,166
Other pulses (*kharif*)	12,544	1,25,530	1 39,074
Other pulses (*rabi*)	2,856	16,176	19,032
Total	...	...	34,71,348

PLATE XIII



Even the unpalatable *Lantana camara*, a common invader in the forests of Northern India, is browsed when pasturage is scarce.—Simla Hills, Punjab

Photo : N. G. Pring

After the grain crops, fodder crops come next in importance in the Punjab, covering 14 per cent of the total crop area, equivalent to 1,997,800 acres (850,000 irrigated, 1,143,000 non-irrigated). As the stalks (*kadbi*) of *juar* grown for grain are also used as fodder, that acreage may be added (total 590,000 ; irrigated 103,000, non-irrigated 486,000).

TABLE XXI

Acreage of leguminous fodder crops in the Punjab

Crop	Irrigated	Non-irrigated
Guar	1,49,981	1,38,206
Moth	31,446	38,568
Senji	38,411	1,134
Berseem	1,18,241	—
Shaftal	9,086	—
Metha	—	22,916
Lucerne	13,482	72

In addition to the main crops listed in Table XXI, the following are also grown :

Chari (great millet grown alone or mixed with *guar* for fodder, cut before it seeds).

Oats

The average yields in grain and green fodder of the main crops are given in Table XXII.

TABLE XXII

Yields of grain and green fodder in Punjab

Crops	Irrigated	Non-irrigated
Grain (in lb. per acre)		
Gram	833	537
Mung	450	274
Mash	540	132
Massar	750	440
Other pulses	675	370

TABLE XXII—(*contd.*)

Yields of grain and green fodder in Punjab

Crops	Irrigated	Non-irrigated
Fodder (in maunds per acre)		
Guar	300	150
Moth	250	100
Beans	250	100
Senji	250	150
Berseem	600	...
Shaftal	400	...
Metha	250	100
Lucerne	500	...
Field peas	250	150
Chari-guar mixture	350	200

Rotations are of most significance under irrigation, and are determined by the cropping system to be adopted and the facilities for irrigation and manuring.

Wheat/maize/*senji*/cotton	4 crops in 4 years
Wheat/maize/*senji*/cotton	4 crops in 3 years
Maize/*senji*/cotton	3 crops in 2 years
Wheat/maize/*senji*/sugarcane	4 crops in 3 years
Chari-guar mixture/gram/cotton	3 crops in 2 years
Oats or wheat/fallow/berseem/*juar*	4 crops in 3 years
Juar/berseem	2 crops in 1 year
Juar/gram/fallow/wheat	
Oats/fallow/berseem.	
Juar/fallow/cowpeas.	

TABLE XXIII

Number of livestock of different types in Punjab

Class of livestock	Males	Females	Calves up to 3 years	Total
Cattle	16,90,893	10,57,601	13,52,182	41,00,676
Buffaloes	1,91,593	14,63,930	12,70,889	29,26,402
Horses	30,121	46,716	14,318	91,155
Mules	...	...	...	8,661
Donkeys	...	...	...	1,43,915
Sheep	...	...	...	9,49,810
Goats	...	...	...	16,51,792
Camels	...	...	...	1,16,471

PLATE XIV

Pasture experimental area on trap formation at Nagpur, Madhya Pradesh, in which the principal tree species is *Acacia leucophloea*

Photo : A. L. Griffith

In the hill districts of the Punjab, livestock are maintained on grazing during the summer, and on grass hay or maize or rice stalks in winter, in both irrigated and dry farming conditions, rural or urban. In the plains they are largely stall-fed in the irrigated areas, kept on grazing and *kadbi* in the non-irrigated land in the rural areas, and stall-fed in the urban areas. Non-working cattle pasture in the grazing grounds and waste lands during the day and receive some concentrate or dry stalks at night if available.

Fodder Production in Uttar Pradesh

A similar position exists in the western districts of Uttar Pradesh. It is only in this part of the State that crops are grown exclusively as fodder. Excluding the area in the immediate vicinity of large towns or cities where fodder crops are raised for sale in the market throughout the year, such crops are mostly grown in the *kharif* season. In most of this region where sugarcane is also an important crop, its tops provide a good source of green fodder from November till the end of March or even later.

In the *kharif* season, sowings have been generally made with the rains, but there has been an increasing tendency in the past few years to grow more early irrigated fodder crops. *Chari* (*Sorghum vulgare*) is by far the most important *kharif* fodder crop in the region but on non-irrigated land, too light for *chari*, *bajra* is often sown. *Bajra* may also be sown on good irrigated land early in summer to provide early fodder as a substitute for early maize, since this crop is not generally favoured by the cultivators because of its higher requirements for manures and irrigation.

On irrigated land on loam to light loam soils, the following legumes are sown in the *kharif* season mixed with crops such as *chari* or *bajra* :

(i) Chari/*cowpea* : This is the most common mixture usually sown under irrigation during the first fortnight of June, in order to provide an early and secure source of fodder. If the crop is sown later, *moth* (*Phaseolus aconitifolius*) is also added to the mixture.

(ii) Bajra/*cowpea*/moth : This mixture is sown in late May and is expected to give a reasonable yield in July.

(iii) *Cowpea*/moth : This is the earliest mixture to be sown, usually at the beginning of May or in late April. The chief advantage is that, after two or three irrigations, *moth* is ready for thinning within 40 days and supplies a

valuable leguminous supplement to the wheat-straw feed of cattle from the last week of May until about the end of July. It can be thinned several times, and after each thinning the remaining plants grow rapidly in size and cover the exposed ground. Towards the middle of July it begins to rot because of the heavy rains and cowpea can then be cut and fed to cattle mixed with the wheat-straw.

(iv) Chari/guar : This mixture may be sown under irrigation, but it is gradually losing ground in favour of cowpea on rain-fed land.

The following are the most important mixtures :

Chari/guar *Chari*/cowpea *Chari*/black gram	On level land which is not very light and which receives irrigation in other seasons
Bajra/guar *Bajra/chari/guar* *Bajra/chari*/cowpea/*guar* *Bajra/moth*	On light sandy soils that are usually not level and are never irrigated.

The legume is added to the first three mixtures in order to supplement the yielding capacity of the non-leguminous component and to improve the quality of the produce, but in the last four mixtures, the legume is as important for grain as the non-legume, since in many years it is only the legume, and especially *guar* and *moth*, that prevent a total loss due to deficiency of rain. The non-leguminous component may frequently be harvested separately and fed to the cattle while the legume may be left to mature seed.

During the *rabi* season, only leguminous crops such as berseem, *moth* or *metha* and peas are grown for fodder in Western Uttar Pradesh, since sugarcane tops supply the bulk of the fodder requirements. Only rarely are oats grown for this purpose. In all the canal tracts of this region on light soils, peas predominate, but *moth* takes their place on heavier soils. Berseem is grown only where less frequent irrigations are needed or where tube-well irrigation is available.

There is considerable scope for extending the cultivation of berseem. *Moth* and berseem are usually sown pure but rape or mustard is usually mixed with peas.

Fodder production in Madras

For purposes of comparison we will now consider the position in Madras as representative of conditions over a great part of Southern India. Taking figures

PLATE XV

Deserted fields and heavy grazing.—Kangra Division, Punjab

Photo : Forest Research Institute

for 1944-45, Krishnaswamy, V. S. and Venkataramana Reddy (1953) show that, out of a total area of 37 million acres under cultivation in the State before the creation of Andhra State, 460,000 acres were under fodder crops. The majority of the cattle depend only on straws, haulms and *bhusas*. The Madras Fodder and Grazing Committee showed that, out of a total fodder production from all sources of about 34 million tons, the dry roughages, i. e. almost wholly crop residues, accounted for 21 million tons.

Even 34 million tons represent only about five lb. per day per cow unit. It is reckoned that the livestock can obtain adequate sustenance from grazing on the natural grasslands for about 60 or 70 days per annum. To improve the fodder resources, the total quantity of crop residues produced would as a first step have to be increased considerably ; these residues will increase only if food crop production increasess ; the cultivation of food crops has already extended to marginal and sub-marginal lands, so that any increase in food crops can be achieved only by adopting more intensive methods of cultivation. But even with these measures, there will still be insufficient quantities of crop residues. So the combined approach recommended by Krishnaswamy and Venkataramana Reddy should be to increase fodder supply for private lands by :

(a) adoption of measures to increase the yield of food grains and so of crop residues ;

(b) inclusion of a fodder-cum-green-manure crop in the cropping cycles, and

(c) growing a fodder-cum-green-manure crop pure in part of an individual holding.

The proposals can be only tentative. The ryots do not realize that even in normal years there is serious under-production of fodder in the State, and that the deficit is colossal. Most Collectors report that there have generally been no complaints from the public regarding deficiency of fodder in normal years ; only in years of extreme drought does agitation arise for supplies of fodder. "In a way the ryot cannot blame anybody except himself, for it is only he that has to grow the fodder necessary for his cattle in his field. Apart from this, the average ryot has become more money-minded. Direct money returns are what he cares for and not indirect benefits. A certain amount of ignorance also exists in matters relating to cattle feeding and fodder production."

Elsewhere we indicate that perhaps he realizes that most of his cattle are hardly worth feeding. At present they are neither well-fed nor well-cared-for. They are generally let out to wander in the village fields when these are not under a crop and allowed to scrape up whatever food they can find. No care is taken about their breeding, any scrub bull being allowed to serve, producing miserable offspring.

According to Krishnaswamy and Venkataramana Reddy, there is no doubt that fodder crops are available for introduction into mixed farming practice if required. In the Tungabhadra Project area, for example, the normal manurial requirements are 40 lb. N per acre for cereals and 60 to 80 lb. per acre for Cambodia cotton. The use of a green-manure-cum-fodder crop would be of great value in the area.

Fodders which have succeeded in the Siruguppa farm are given in the following Table :

Types	Sowing season	Net yield in lb. per acre
Jonna (*Juar*)	June to August	10 to 30,000
Maize	June to October	12 to 15,000
Lucerne	Throughout the year	12 to 15,000
Guinea grass	Throughout the year	15 to 20,000
Napier grass	Throughout the year	10 to 15,000
Berseem	September to October	8 to 10.000
Pillipesara	June	8 to 10,000
Cowpea	June	8 to 10,000
Cluster bean (*guar*)	March to May	6 to 18,000
Sunnhemp	March to May	4 to 6,000

On the West Coast in Malabar, fodder is also in short supply and calcium and phosphorus deficient in the soil. There is ample grass during the monsoon and for two or three months thereafter, but little from then until the next monsoon. Water is not available or difficult in supply. It is suggested that a legume such as horse gram might be grown in rotation with paddy, the main crop of Malabar.

PLATE XVI

Unplanted and heavily grazed area.—Pabbi Forest ,Shahpur Division, Punjab

Photo : Fazluddin

Krishnaswamy and Venkataramana Reddy state that what is really necessary is a composite plan for maximum production of food and fodder; competition between cash crops and food crops would have to be reconciled in the interests of national economy, while allowing maximum return to the ryot. Agricultural working plans would have to be prepared.

Research on Fodder Crops

In spite of the great importance of cultivated fodders in the development of the grazing and fodder resources of India, it cannot be said that these crops are receiving the attention they deserve. The Indian Council of Agricultural Research has a model scheme for work in States which is rather restricted in its scope. The Fodder Botanist, Punjab, and the Teaching Botanist, Nagpur, are concerned with short term and other fodder crops. The Government of Uttar Pradesh has evolved a comprehensive overall scheme involving co-operation between the Departments of Animal Husbandry, Agriculture and Forestry; the necessity of such an approach is stressed by Krishnaswamy and Venkataramana Reddy (1953) for Madras.

In addition to his work on grasses and grassland management described in Chapter XIV, the Teaching Botanist, Nagpur, is studying various fodder species adapted to Madhya Pradesh. Strains of *rabi juar* have been evolved for producing green fodder or grain plus dry fodder. Promising strains of legumes are being tested in randomised replicated blocks against existing improved varieties for yield of seed, seed and *kutar*, and green fodder. Improved types of *Dolichos lablab* and soybean have been produced; comparative yields of green fodder per acre from a species comparison are; *Dolichos lablab* 18,550 lb.; *kachkari* 17,866 lb.; soybean 16,939 lb. and *guar* No 5, 14, 529 lb. Preliminary trials with early-maturing *mung* strains showed Mg. 7 and 10 to be superior. Among *rabi* fodders, e. g. lucerne, berseem and *senji*, lucerne strains Nos. 3, 7 and 5 gave 33.816, 33,247 and 29,391 lb. green fodder per acre compared with 27,443 for the control. Mixing rape with the local variety increased the yield by 18 per cent.

Tables XXIV—XXVII give information obtained by Patel, Patel and Patel (1950) on the effect of cutting Guinea, Napier and elephant grasses at different stages of growth or at different intervals on their yield and percentage leafiness.

Table XXIV

Green yield per acre of grasses cut at different intervals

Fodder grass	Intervals of cuttings (Days)	1944-45 (lb.)	1945-46 (lb.)	1946-47 (lb.)	Average of three years (lb.)
Guinea grass	30	33,515	17,020	21,589	24,041
	50	32,625	15,792	17,709	22,022
	70	31,277	22,199	20,565	24,680
Napier grass	30	31,513	19,561	15,856	22,310
	50	33.380	20,393	16,326	23,366
	70	27,693	21,054	18,163	22,303
Elephant grass	30	45,794	19,622	8,163	24,562
	50	16,473	29,231	17,266	20,990
	70	17,973	23,491	10,848	17,437

Table XXV

Green yield per acre of grasses harvested at different stages of growth

Fodder grass	Stage of growth	1944-45 (lb.)	1945-46 (lb.)	1946-47 (lb.)	Average of three years (lb.)
Guinea grass	Leafy	37,547	37,097	20,670	31,781
	Boot-leaf	38,145	17,022	11,802	22,625
	Inflorescent	33,180	26,304	30,042	29,850
	Post-bloom	22,806	22,629	8,922	17,452
	Mature	17,949	18,751	9,396	15,364
Napier grass	Leafy	30,304	42,603	25,855	32,920
	Boot-leaf	27,603	16,145	18,540	20,763
	Inflorescent	21,875	15,080	25,151	20,702
	Post-bloom	26,436	14,248	11,616	17,433
	Mature	21,584	17,736	13,189	16,836
Elephant grass	Leafy	43,523	56,217	13,102	37,614
	Boot-leaf	34,509	16,795	19,627	23,644
	Inflorescent	40,304	12,496	13,344	22,048
	Post-bloom	31,723	14,412	8,902	18,346
	Mature	35,375	16,239	12,646	21,420

PLATE XVII

Denudation at about 8,000 feet on a heavily overgrazed Eastern slope in the Simla Hills. Erosion in progress, criss-cross cattle paths, and closely cropped thron bushes

Photo: T. V. Dent

TABLE XXVI

Percentage leafiness at different intervals of cutting

Fodder grass	Intervals of cuttings (Days)	Percentage of leafiness			
		1944-45	1945-46	1946-47	Average
Guinea grass	30	50.9	78.4	100.0	76.7
	50	52.8	55.0	65.5	58.0
	70	44.3	47.1	58.7	50.0
Napier grass	30	63.3	77.5	100.0	80.3
	50	53.4	65.4	55.6	58.1
	70	57.9	38.3	63.8	53.3
Elephant grass	30	42.7	57.6	100.0	66.8
	50	48.7	38.9	54.9	47.5
	70	37.3	40.9	52.9	47.7

With the two strains of *Pennisetum purpureum*, both yield and leafiness with either plan of cutting were low. Guinea grass is best because of its higher crude protein content ; it gives the best forage value when first harvested between pre-shooting and boot-leaf stage and subsequently when cut at monthly intervals. These results should be compared with those obtained in Trinidad, B. W. I. by Paterson (1933 and 1944).

TABLE XXVII

Percentage leafiness at different stages of growth

Fodder grass	Stage of growth	Percentage of leafiness			
		1944-45	1945-46	1946-47	Average
Guinea grass	Leafy	43.2	58.5	100.0	67.2
	Boot-leaf	39.9	33.5	48.0	7.1
	Inflorescent	37.7	49.0	53.4	46.7
	Post-bloom	27.7	49.0	50.6	42.4
	Mature	21.3	48.9	54.5	41.6
Napier grass	Leafy	47.6	55.2	100.0	67.6
	Boot-leaf	22.3	47.6	52.1	40.7
	Inflorescent	17.2	45.5	44.0	35.6
	Post-bloom	13.9	41.5	41.7	32.4
	Mature	13.9	43.9	37.7	31.8
Elephant grass	Leafy	30.3	49.5	100.0	59.6
	Boot-leaf	25.7	48.8	48.1	40.9
	Inflorescent	14.6	48.1	42.2	34.9
	Post-bloom	12.6	46.9	41.4	33.6
	Mature	10.0	47.3	36.3	31.3

Time of cutting trials have also been reported by Seth (1952) for some indigenous and exotic grasses grown under agricultural rain-fed conditions in the Clutterbuckganj nursery at Bareilly, in Uttar Pradesh. The green and dry weights obtained in maunds per acre are given in Table XXVIII.

Plate XVIII

A general view of hillside vegetation near Bhowali, Naini Tal district, Uttar Pradesh. The typical terraced cultivation practised in the hills is clearly shown. The crops are usually finger millet (*Eleusine coracana*), grain amaranth (*Amaranthus paniculatus*) and Italian millet (*Setaria italica*), etc.

Photo : D. Chatterjee

TABLE XXVIII

Effect of frequency of cutting on yield of grasses C

(Maunds per acre)

Species	Year										
	1945			1946			1947			194…	
Indigenous:	I*	II†	T‡	I	II	T	I	II	T	I	II
Bothriochloa intermedia	332	134	466	228	121	349	283	134	417	332	[illegible]
	133	69	202	119	54	173	126	70	196	147	[illegible]
Bothriochloa pertusa	90	57	147	97	46	143	152	23	175	184	[illegible]
	41	27	68	59	21	80	56	14	70	77	[illegible]
Cenchrus ciliaris	273	145	418	109	89	198	149	66	215	172	[illegible]
	71	76	147	56	36	91	55	31	86	46	[illegible]
Dichanthium annulatum	181	82	263	94	65	159	163	50	213	196	[illegible]
	61	35	96	44	29	73	63	31	94	47	[illegible]
Eremopogon foveolatus	77	77	154	63	63	126	133	31	164	108	
	35	38	73	31	30	61	42	19	61	45	
Iseilema laxum	103	81	184	67	41	108	112	39	151	109	
	26	46	72	33	26	59	33	20	53	43	
Exotic:											
Cynodon plectostachyum	68	74	142	74	39	113	83	21	104	95	
	27	33	60	42	27	65	30	15	45	24	
Digitaria seriata	199	115	314	189	86	275	280	89	369	251	
	61	56	117	84	42	126	93	37	130	87	
Digitaria swazilandensis	115	49	164	77	52	129	126	47	173	126	
	42	28	70	40	27	67	42	26	68	44	
Melinis minutiflora	...	...	...	147	52	199	205	5	210		
				116	13	129	73	4	77		
Panicum maximum	150	98	248	112	66	178	185	82	267	161	
	50	45	95	46	30	76	66	42	108	73	

(*I—1st cut in July-August; II†—2nd cut in October-November, ; T‡—Total of both cuts)

TABLE XXVIII

Effect of frequency of cutting on yield of grasses Clutterbuckganj, U. P.
(Maunds per acre)

Species	1945			1946			1947			1948			1949			Average			Average for one cropping
	I*	II†	T‡	I	II	T	I	II	T	I	II	T	I	II	T	I	II	T	
Indigenous :																			
Bothriochloa intermedia	332	134	466	228	121	349	283	134	417	332	98	430	410	206	616	317	138.6	455.6	359
	133	69	202	119	54	173	126	70	196	147	45	192	154	59	213	135.8	59.4	195.2	
Bothriochloa pertusa	90	57	147	97	46	143	152	23	175	184	54	238	160	87	247	136.6	53.4	190	128
	41	27	68	59	21	80	56	14	70	77	30	107	62	26	88	59	23.6	82.6	
Cenchrus ciliaris	273	145	418	109	89	198	149	66	215	172	41	213	155	79	234	171.6	84	255.6	158
	71	76	147	56	36	91	55	31	86	46	14	60	30	24	54	51.4	36.2	87.6	
Dichanthium annulatum	181	82	263	94	65	159	163	50	213	196	59	255	158	63	221	158.4	63.8	222.2	160
	61	35	96	44	29	73	63	31	94	47	26	73	61	41	102	55.2	32.4	87.6	
Eremopogon foveolatus	77	77	154	63	63	126	133	31	164	108	38	146	94	54	148	95	52.6	147.6	91
	35	38	73	31	30	61	42	19	61	45	21	66	31	23	54	36.8	26.2	63	
Iseilema laxum	103	81	184	67	41	108	112	39	151	109	62	171	128	97	225	103.8	64	167.8	97
	26	46	72	33	26	59	33	20	53	43	26	69	28	24	52	32.6	28.4	61	
Exotic :																			
Cynodon plectostachyum	68	74	142	74	39	113	83	21	104	95	19	114	140	27	167	92	36	128	...
	27	33	60	42	27	65	30	15	45	24	12	36	30	13	43	30.6	19.2	49.8	
Digitaria seriata	199	115	314	189	86	275	280	89	369	251	98	349	251	115	365	234	100.6	334.6	107
	61	56	117	84	42	126	93	37	130	87	42	129	70	35	105	79	42.4	121.4	
Digitaria swazilandensis	115	49	164	77	52	129	126	47	173	126	52	178	108	87	195	110.4	57.4	167.8	92
	42	28	70	40	27	67	42	26	68	44	21	65	35	26	61	40.6	25.6	66.2	
Melinis minutiflora	...	...	...	147	52	199	205	5	210		...	...	180	7	187	106.4	12.8	119.2	...
				116	13	129	73	4	77				82	4	86	54.2	4.2	58.4	
Panicum maximum	150	98	248	112	66	178	185	82	267	161	70	231	182	110	292	158	85.2	243.2	122
	50	45	95	46	30	76	66	42	108	73	48	101	49	47	96	56.8	38.4	95.2	

(*I—1st cut in July-August; II†—2nd cut in October-November, ; T‡—Total of both cuts)

Two cuts following the rains are undesirable as the yield from a single cut at maturity is greater than the combined yield for two successive cuts, and the seasonal cut is usually slight. The same result was obtained when cuts were taken in summer (June) and winter (November). It would be interesting to compare these results on the basis of yield of protein per acre.

Crop Residues

The strains, haulms and stalks of the cereal crops which provide by far the greatest amount of India's fodder resources need not be discussed at any length, as they are dealt with fully in other chapters. Studies on the quality of cereal and particularly rice straw are discussed in Chapter IV. The use of *bhusa, kadbi* and other residues in rations as an important part of the fodder calendar is described in Chapter VIII. There is no doubt that these residues must remain a basic part of India's fodder ; their amount and perhaps also their quality will be related to any steps which may be taken to intensify cereal production, particularly by the application of fertilizers.

Natural grass hays

Agricultural planners concerned with the fodder crisis in India always look towards the grass areas in the forests which are either closed to grazing or inaccessible within the daily ambit of village cattle. So much damage has already been done by grazing in forests that any extension of the practice cannot be supported. It then becomes a question whether it is possible and economic to go into these forest areas, cut the grass in its mature state (3 to 4 per cent protein) and transport it to the centres of population for issue to villagers or retention in State-maintained fodder reserves.

The desirability of cutting forest grass in preference to grazing is discussed in Chapter XI, where it is pointed out that cutting is not deleterious to forests, but that grass cutting will not replace grazing until the villagers come to have only picked animals for which grass cutting is worthwhile.

In forest areas closed to grazing permanently or temporarily for silvicultural reasons, grass cutting is generally allowed in order to reduce the risk of fire. Edible grasses so cut are used as fodder and the inedible ones for thatching, rope-making, etc. In Bombay, Hyderabad, Madhya Pradesh and, perhaps, in other States of Western India as well, open grasslands are maintained as *kurans,*

was sent to three distributing centres but was difficult to sell. About 15 tons were sold for Rs. 122/- (against Rs. 175/- which was the actual cost of cutting, stacking and transport). The remaining grass was either sold at very low rates or given away free. In this case the failure of the operations would appear to have been due to (1) absence of pronounced scarcity of fodder and (2) late cutting of grass after it had seeded and become coarse. (Forest Officers' Conference, 1946).

In Madhya Bharat, a number of grass *birs* are maintained by the Forest Department for production of fodder grass for stall-feeding in each division. The State is a normal exporter of fodder grass to other States like Saurashtra Rajasthan, Ajmer and Kutch. In 1951-52, in addition to local requirements, 27, 954, 769 lb. of fodder grass were baled mostly for export. In 1942, five lakh maunds of grass and straw were collected in Gwalior forests at a cost of Rs. 1/12/- per maund.

The cutting and conversion of grass into hay and straw for storage and export are in vogue on an appreciable scale only in a few States ike Madhya Bharat. Elsewhere, they are practised only in times of acute fodder scarcity. Ensilage is practically unknown in forests except for certain experimental operations which were none too encouraging.

If silage and hay are to become regular forms of use of forest grass, every effort must be made to induce the villagers to manufacture them. The grass may be given free and permission accorded to construct silos within the forests. The department may even meet the expense of silo-construction (Krishnaswamy, V. S. and Venkataramana Reddy, 1953).

Bombay Grass Industry

The supply of natural grass hay or straw for the livestock in and around Bombay city has become the basis of a very considerable industry. Each day throughout the year, some 120 railway trucks bring grass hay to four railway stations in Bombay and Greater Bombay, plus 30 to 40 to the Aarey Milk Colony. The great bulk of this grass hay or rather grass straw, since it is dry and mature before it is cut and is of low protein content, is composed of three main types :

Common names	*Latin names*
Phul	*Pseudanthistiria heteroclita* and *Themeda triandra*
Bher	*Ischaemum rugosum*
Mushi	*Iseilema wightii*

Of the total weight of grass received in Bombay approximately 50 per cent is *phul*, 25 per cent a mixture of all four grasses (predominantly *phul*), 15 per cent is a mixture of *bher* and *mushi*, and 5 to 10 per cent is pure *mushi*. A wagon holds 15,000 lb. of *bher* but only 8,000 to 10,000 lb. of *phul*. The grass (daily requirement of greater Bombay is about 2 million lb.) comes from stations in the Thana and Surat Districts along the coastal strip north of Bombay city on the Western Railway (old B. B. and C. I.), i. e. from the stations from Sophala to Billimora. At the time of inspection (January, 1952), the best grades were selling for a ceiling price of Rs. 48/- per 10,000 lb. while the poorest samples (*Eragrostis*) were around Rs. 26/-. Bales of the best grades weigh about 225 lb. each.

Since Bombay dairymen state that cattle receiving *mushi* and *bher* give 40 per cent more milk than those receiving *phul*, a desirable research objective would be to discover by analysis and feeding trials why this is so. The grassland ecologist should investigate the reasons for the predominance of *phul* in the areas of harvest-ing, and whether any change in management practices would reverse the supposed trend or retrogression towards dominance of *phul* and increase the percentage of the superior *mushi* and *bher* in the grasslands and, therefore, in the supplies reaching Bombay.

It may well be that the continuous remova of grass straw crops over many successive years represents a considerable drain on soil nutrients. The trials reported in Chapter XIII indicate that, on this type of vegetation, there is a substantial increase in the yield of grass following the application of nitrogen ; an application of farmyard manure plus sulphate of ammonia at 30 lb. N per acre gives a 20 per cent increase in yield ; the response is further increased by the addition of superphosphate. There is no indication of the effect of fertilizers on the botanical composition of the sward and the cut hay.

The botanical composition may perhaps be influenced by adjusting the

dates of cutting and by the introduction of superior species into poor stands. There is a range in the dates on which the various grasses are harvested. It is possible that the grass harvester is unintentionally favouring the dominance of undesirable types by cutting earlier and earlier. The earlier the cuts, the less chance do the remaining plants of *bher* and *mushi* have to produce seed and perpetuate themselves.

It may be considered desirable to introduce superior species like *bher* and *mushi* into grassland areas containing inferior species. Since it is difficult to collect seed from these species, vegetative reproduction is the only method to adopt at present. When it is proposed to apply manure and/or fertilizers to a stand in which *phul* is dominant, a change in botanical composition may be accelerated by planting cuttings of *bher* and *mushi* in spaced plough furrows made across the prevailing wind ; the shattering habit of *mushi* in particular may lead to its spread between the rows.

Tree Fodders

In North India, grasses become useless with the onset of winter, with the result that cattle must seek an alternative fodder. In the absence of grass stored as hay or silage, cattle must depend for about six months of the year on leaf-fodder, agricultural by-products and green fodder crops (Chaturvedi, 1948). In the inner Himalayas each farm has its own allotted broad-leaved trees, particularly the evergreen oak. These are lopped on a regular rotation and carefully preserved. Great care is taken to lop the branches in such a way as to extend the crown. In the common village pastures and in the forests, on the other hand, no such care is taken and no tree is spared (Glover 1946). In the central and southern parts of the country fodder-leaves are fed to cattle to an extent varying with the availability of grass and agricultural fodder. While trees in private lands are everywhere left alone, those in avenues, common village lands and forests are ruthlessly lopped for fodder. In the Punjab where the damage done to the oak and *Olea* forests is considerable, a constructive attempt has been made in Kangra to minimise this vandalism by encouraging the ryots to plant fodder trees in their own lands and, co-operatively, in waste lands owned by them with others of the village.

The basic principle underlying lopping regulations is that the trees get the necessary rest to enable them to recover from the damage caused by lopping. The

technique developed in Saharanpur should serve as standard. Its salient features are :

(1) certain valuable species are declared as protected from lopping ;

(2) no lopping should be permitted in areas liable to erosion, where all vegetation is carefully nursed ;

(3) saplings and small poles should not be lopped ;

(4) the upper one-third of the crown of all trees is protected from lopping; branches over three inches in diameter in the lower two-thirds of the crown may not be cut ; and

(5) a cycle ensuring complete rest for two growing seasons should be prescribed.

In the Kangra Working Plan, a rotation or lopping cycle of three years has been adopted in the working of the oak forests for fodder. The same lopping cycle has been adopted in Kalesar R. F. of Ambala Forest Division, the species to be lopped being *Bauhinia vahlii*, *Garuga pinnata*, *Grewia oppositifolia*, *Kydia calycina*, *Stereospermum suaveolens*, *Bauhinia racemosa*, *Aegle marmelos*, *Nyctanthes arbortristes*. *sal*, *khair*, *toon*, *Adina*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Sissu*, *Ougeina dalbergioides*, *Terminalia chebula*, *Terminalia belerica* and bamboo should not be lopped. No tree under four feet in diameter at breast height should be lopped, the upper one-third of the crown of a tree must not be lopped ; no branch over three inches in diameter or nine inches in girth may be cut. The lopping season is to be from the 15th November to 15th March.

Laurie as Central Silviculturist has published a useful list of fodder trees in India (Laurie, 1939).

The growing importance of leaf fodders in the livestock economy of the country has necessitated supplementing the natural resources of fodder trees by plantations. In Saharanpur Division of Uttar Pradesh the proportion of lopping species varies from 40 to 60 per cent by area in the taungya working circle. The following are the fodder trees raised :

Kydia calycina, *Moringa pterygosperma*, *Ficus glomerata*, *Terminalia belerica*, *Albizzia procera* and *Azadirachta indica*. In Bahraich Division (U. P.), the following fodder lopping species are being raised in the plantations :

Terminalia tomentosa, Schleichera rijuga, Albizzia lebbek, Ficus glomerata, Pterocarpus marsupium, Bassia latifolia, Morus alba and *Azadirachta indica* (*Silv. Conf.* 1941).

In Kurnool East Division, the following fodder and manure leaf species are being introduced in fuel coupes by the 'taungya' method : *Albizzia lebbek, A. amara, Poinciana elata, Bauhinia purpurea, Hardwickia binata, Azadirachta indica, Cassia siamea, Sapindus emarginatus,* etc. Fodder species are being tried in fuel plantations in many other Divisions of Madras and other States as well.

In parts of Madras, lopping of trees for manure and fodder is permitte in fuel coupes under felling, just ahead of the fellings. This makes it possible to utilize leaves which would otherwise be wasted. Mahendra Prakash (1951) has suggested that in Rajasthan fuel coupes might be opened to lopping the year previous to that in which they are to be felled and that the lopping might be done during summer, when the *birs* are closed for the monsoon. This is certain to be welcomed by graziers who are hard pressed for fodder in that season.

On the whole, fodder from trees and shrubs may be regarded as a scarcity fodder in India (*Comm. Agric. Bur.* 1947). It is used only in the seasons when grass is scarce or altogether unavailable, as happens in the dry months in the southern parts of the country and in winter in North India. As rains are confined to the monsoon period, the dry season is prolonged. As hay making and ensilage are not practised, leaf fodder is the only alternative to grass. In some areas like Orissa, flooding of the pastures during the monsoon is an additional reason why leaf fodder becomes indispensable. Exceptionally in some places, fodder from trees and shrubs is used as a regular practice, i. e. in places such as some hill districts where there is little or no grass. In the Kangayam area of Coimbatore District in Madras State, which has already been referred to in connection with one of the rare instances of artificial pastures in India, the high-grade cattle are fed regularly with pods of *Acacia leucophloea*. Breeders say that this gives an extra bloom to their coats. In parts of Salem and North Arcot Districts, there is a breed of cattle which feed almost exclusively on the shoots and leaves of *Albizzia amara* even where grass is available.

Apart from a few exceptions like these, tree and shrub fodder is a scarcity fodder. Even as such it is indispensable under present conditions. In the reserved forests, lopping of trees is mostly forbidden. In some places it is

regulated, some species being completely protected while others are lopped either in rotation or in specified ways, such as lopping of small twigs in the lower portion and prohibiting it in the upper third of the crown altogether. In private forests, scrub jungle, waste land and by roadsides, there is little attempt at regulation, with the result that trees are often lopped to death. The general belief is that the demand for tree and shrub fodder is likely to decrease as pasture management improves and methods of fodder storage become popular. In the meantime the policy is to regulate lopping where it is unavoidable and to grow fodder trees along with other species in plantations, particularly in the dry districts, so as to create a reserve against periods of acute scarcity.

CONCENTRATES

The feeding rations and fodder calendars given in Chapter VIII show the important role of concentrates of all kinds in the improved feeding of livestock in India. Their importance is greater in India than in many other more favoured livestock countries because of the limited nutritive potentialities of the natural grasslands and the great discrepancy between supply and demand as far as cultivated high-protein fodders are concerned. The present position with regard to concentrates is best seen in the report of the Joint Committee on Human and Animal Nutrition (Government of India, 1952).

Oilcakes are one of the major items in the new feeding plan proposed by that Committee. Even with this rational plan of feeding and the utmost economy in concentrate feeds, at least eight million tons would be required to sustain the animal labour and the animal production for milk and meat. The average annual production is estimated roughly at two million tons, of which up to 50 per cent is used as manure in the cultivation of cash crops such as sugarcane, tea, coffee, etc. Again we have a great gap between supply and demand. The Committee naturally considers a cessation of the practice of using edible oilcakes as manure, suggesting that all possible means of using cakes from non-edible seeds such as castor and the seeds of various trees should be fully explored.

Owing to the acute shortage of edible oils, it has recently been considered whether it might be possible to recover more oil from oilcakes by adopting the solvent process of oil extraction. The Committee has considered this possibility and finds that solvent extraction promises not only a substantial economic return, but would also make it possible to release someland for food production.

The reduction in oilcake production could be compensated by the use of maize in the feeding of working animals.

Cottonseed is regarded as a valuable feed for milk production, particularly when fed to milch buffaloes. About 70 to 80 per cent of the oil in cottonseed is converted into milk-fat by buffaloes, a high fat percentage being characteristic of buffalo milk produced in the cotton tracts of India. Although there is no justification for the extraction of the 20 per cent oil content of cottonseed by the solvent process, it might be desirable to take out some by the existing crushing methods. A cake containing 10 per cent oil may be sufficient for milch buffaloes; 100,000 tons of cottonseed oil would thus be made available and the loss in feeding rations could be compensated by isodynamic proportions of maize or barley.

Although the position with regard to maize and barley is also critical, the Committee suggests that the foreign exchange obtained from the export of the oil could be used to pay for imports of the cereal grains from countries in which these are in surplus. Because of the shortage of pulses in human nutrition, the Committee hesitates to recommend the use of any significant proportion of the present gram production for cattle feeding.

Bran supplies a fairly large amount of nutrients, is reputed to stimulate milk production and is a mild laxative. Milling of wheat is banned, although it is known that the existing wheat made available for man is not properly utilized, the digestibility of whole wheat being considerably lower than that of milled wheat. The Committee recommends, therefore, that the milling of wheat should be permitted, and the bran thus obtained should be entirely reserved for the use of productive cattle. The position with regard to rice is not so clear and it is difficult to set a standard to which rice should be milled.

CHAPTER VIII

LARGE PRIVATE, GOVERNMENT AND MILITARY FARMS

HAVING indicated in general the nature of Indian grassland and the sources of cultivated fodder crops and by-products from other types of cropping, we will now deal in an essentially practical way with grassland management and fodder production on the large to medium private properties and the State farms belonging to Departments of Animal Husbandry or Agriculture, town-supply milk colonies, and research and teaching institutions. Only a small minority of India's cattle population is maintained in units of this size, but the fodders which are used and the way in which they are fitted into the local cropping system and the pasture and fodder calendar do provide a model and a target for the improvement of the feeding of the great bulk of India's cattle, namely those kept by villagers. This chapter is based upon original information provided in response to a questionnaire.

Government Farms in the Punjab

A general statement of current practices on Government livestock and dairy farms and on the large holdings of landlords has been provided by the Director of Veterinary Services. These are the only farms on which superior feeding practices are followed, by ensuring a supply of green fodder and roughages throughout the year and by maintaining large stocks of the dry roughages. Rotational grazing is practised and crop cultivation is on modern lines with proper rotations. Correctly balanced rations are followed throughout the year, based on the milk yield of the dairy animals and the amount of work done by the working animals.

Government Livestock Farm, Hissar

At the Government Livestock Farm, Hissar, large scale production of fodder is undertaken on about 4,000 acres of canal-irrigated land, in order to maintain a continuous supply throughout the year. Crops are being sown or harvested in practically every month of the year, apart from the cold months of January and February when sowing is not possible. *Juar* and *guar* are the main *kharif* crops, berseem, lucerne, oats, gram, barley and *methi* are the main *rabi*

crops. About two to three lakh maunds of green fodder are produced annually for feeding the farm livestock ; the surplus is allowed to mature into hay, fodder and grains, for use within the Farm.

There are about 31,000 acres of rain-fed *bir* or uncultivated pasture land which provides nutritious and valuable grazing for some 10,000 head. This area also provides hay for the fodder reserve in years of good rainfall. The *bir* is a valuable asset to the Farm at Hissar. The grassland is mostly composed of *Eleusine flagellifera* and *A,islada depressa*, which would be replaced by the superior *anjan* (*Cenchrus ciliaris*) with proper management. Hay-making in the few good years is very important, as the rainfall at Hissar is very low and unreliable.

The type of ration fed to different classes of animals at the Government Livestock Farm, Hissar, are given in Table XXIX. (See page 139).

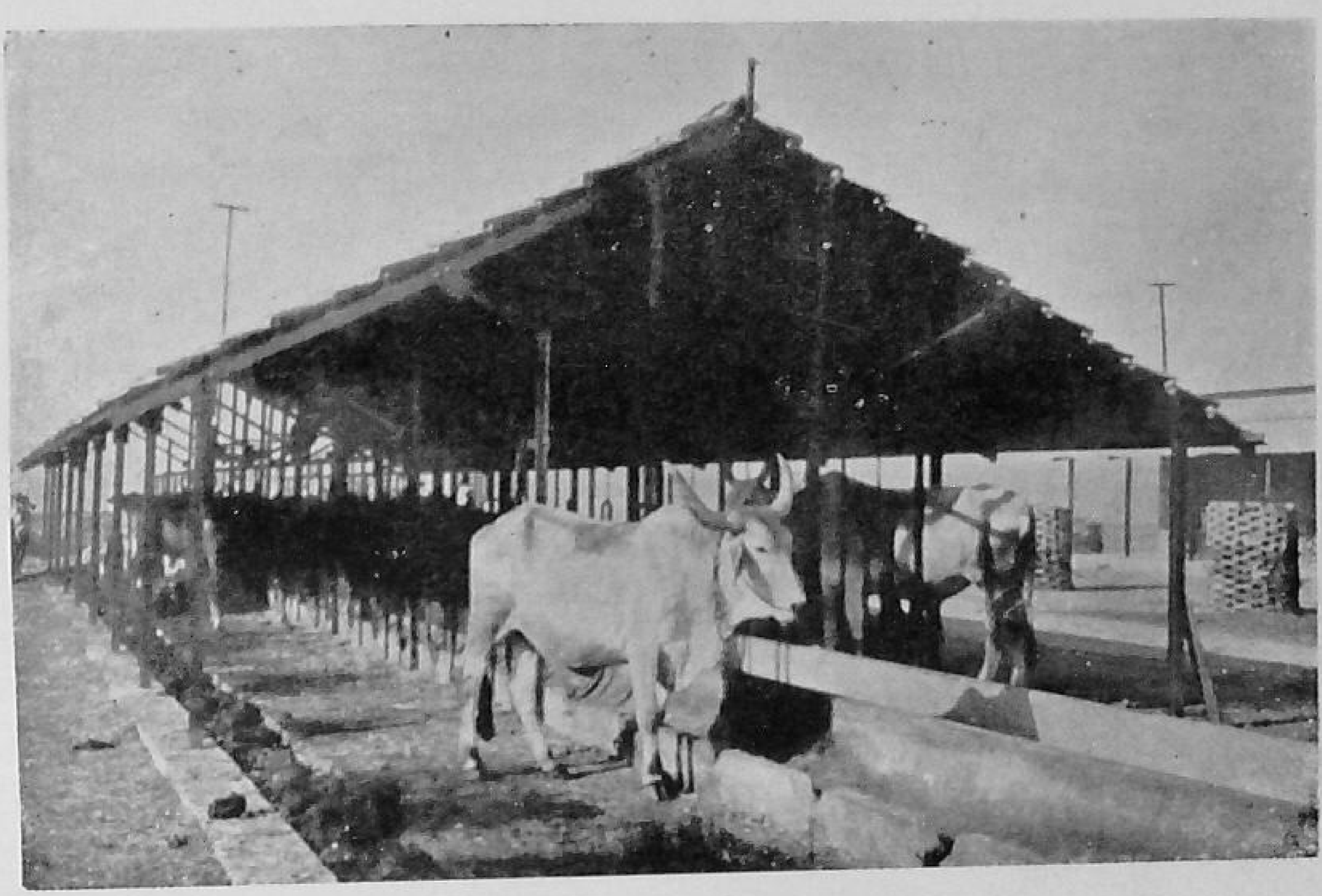
Grazing of the grasslands starts about the middle of July, the herbage remains green until about mid-December, but may then dry up if there are no winter rains. Stubble grazing is available for a month or two after the harvesting of the *kharif* and *rabi* crops.

Berseem is available from mid-November to early May, giving an average of five cuts in this period. It is the best feed for milch and draught cattle. Lucerne is also plentiful during the same season but here, as in many parts of India, is fed only to equines because of the danger of tympanitis. From about mid-May to mid-September, early *juar* and maize are cut and fed green. *Senji* and *methi* become available during the winter months, and give one cut of green odder between January and April, depending upon the time of sowing.

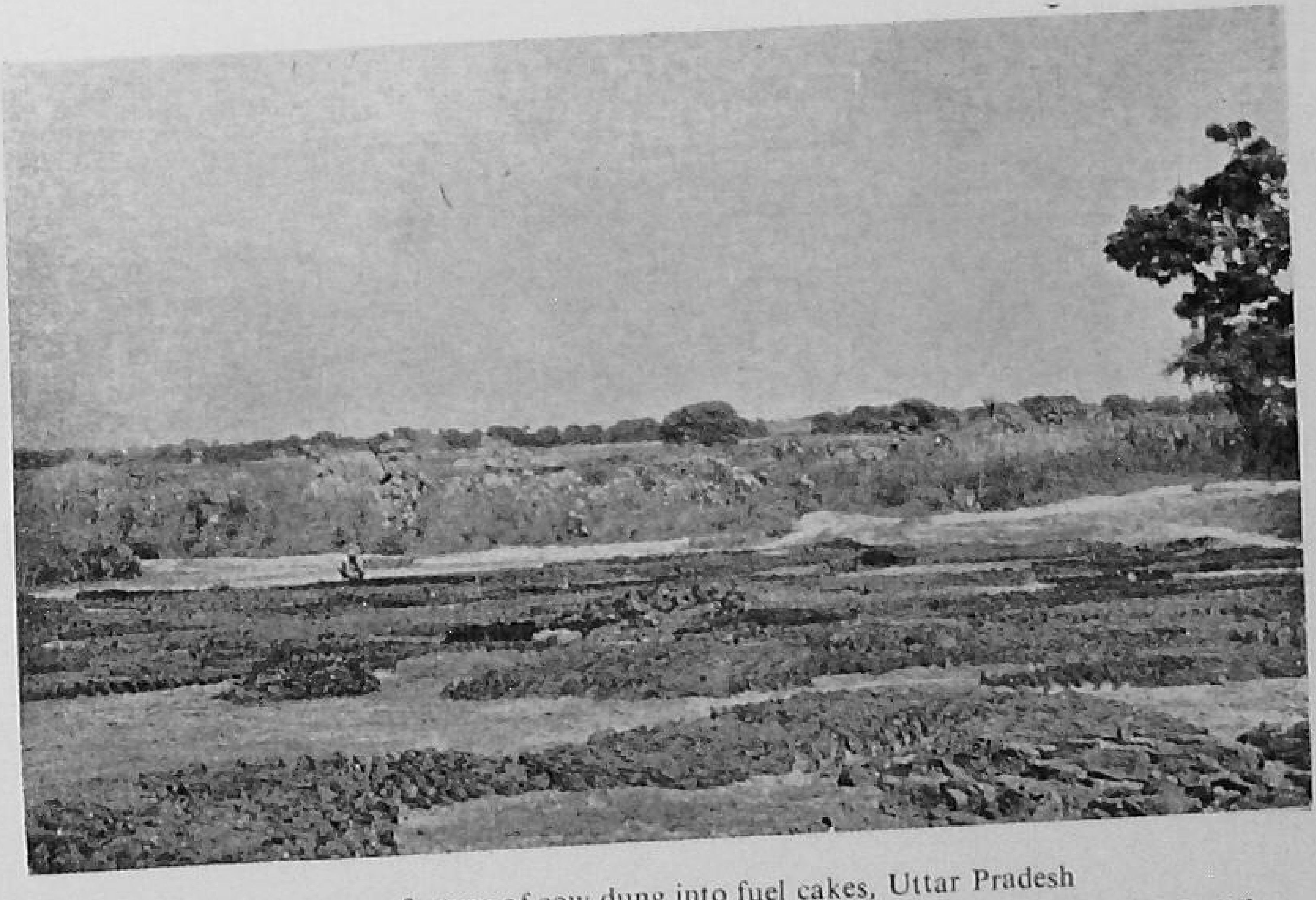
The *kharif* roughages consist of *juar* and *bajra kadbi*, and the *rabi* roughages are gram straw and *bhusa* of wheat and barley. Oats are an important crop at the Government Livestock Farm, Hissar, and the *bhusa* is relished by the cattle and young stock. Peas and *guar* also contribute to the green-feed ration for cattle on Government Farms.

Silage is made on a large scale from *juar* or the natural grasses at the Government Livestock Farm and certain Government dairy farms. Hay is also made from the surplus natural grass which is available after the break of the monsoon. If cut at the proper time (during flowering) and properly cured, it provides a valuable feed in the winter months.

Plate XIX



Open cattle stall at the Agricultural Institute, Naini, Allahabad
Photo : R. O. Whyte



The manufacture of cow dung into fuel cakes, Uttar Pradesh
Photo : R. O. Whyte

TABLE XXIX

Daily rations at Government Livestock Farm, Hissar

Animals	Average Live-weight (lb.)	Roughage		Common salt (oz.)	Concentrates		
		Green or silage (Srs.)	Hay (Srs.)		Gram or *guar* (Srs.)	Barley, oats or bran (Srs.)	Oilcake (Srs.)
Dry cows	800	12	4	2	*nil*	*nil*	*nil*
Milch cows (average yield : 4 seers 5 per cent milk per day)	...	12	4	2	1	½	½
First calvers	...	12	4	2	½	*nil*	½
Breeding bulls	...	12	4	2	1	½	½
Young growing bulls	500	10	3	2	¾	*nil*	¾
Young growing heifers	400	10	3	2	¾	*nil*	¾

TABLE XXX

Acreage (all irrigated) providing green and conserved fodders

Crop	Acres	
Juar	60	*Kharif*
Guar	5	
Cowpeas	25	
Maize/cowpeas	15	
Maize	15	
Berseem	45	*Rabi*
Fodder grasses (Napier and Rhodes)	20	

TABLE XXXI

Fodder calendar for Sahiwal dairy cattle

Month	Fodder
Green	
December to May	Berseem
June / July	Maize / cowpeas
	Fodder grasses
August	*Juar* and *guar*
September / October	*Juar* and cowpeas
November	Cowpeas, fodder grasses
Conserved	
December	*Juar* silage
June	*Juar* silage
October / November	*Juar* silage
June to November	Berseem hay to milch cattle

TABLE XXXII

Ration of green and dry roughage for different classes of livestock (Sahiwal)

Class of animal	Roughage ration in seers per day	
	Green	*Dry*
Cows in milk	40	4
Down calvers	30	4
Dry cows	25	5
Bulls	30	4
Bullocks	25	5
Young male and female stock	15	5
Suckling calves	5	2

TABLE XXXIII

Concentrate rations at Indian Agricultural Research Institute

Class of animal	Oats	Bran	Ground-nut cake	Linseed cake	Gram	Barley	Scale of feeding in lb. per head per day
Milking cows	35	15	20	10	20	...	1 for 2.5 to 3 lb. milk yield*
Down calvers	35	15	20	10	20	...	5 to 10
Heifers covered	35	15	20	10	20	...	3 to 5
Heifers empty	40	10	20	10	20	...	3
Dry cows	35	10	20	10	25	...	3 to 4
Stud bulls	40	10	12	8	30	...	2 to 4
Young bulls	40	10	15	10	25	...	3
Calves (male and female)	35	30	12	8	...	10	(5 linseed) 1/8 to 3

* Grains and concentrates are fed on basis of milk yields; 1 lb. for every 2.5 lb. of milk and 2 lb. for maintenance, with special additional amounts.

Mechanised State Farm, Bharari (Jhansi), Uttar Pradesh

TABLE XXXIV

Estimated area under different fodders required to feed 344 animals (Hariana)

Class of animals	Number	Fodder	Estimated (acreage)		
			Green	*Hay*	*Total*
Growing stock	200	Berseem	55.50	94.00	149.50
Milking cows (7 lb. milk per day)	140	*Chari* (*Sorghum vulgare*)	87.0 (silage)	0.5	87.50
Dry cows	6	Mixed	50.00	43.73	93.75
Stud bulls	4	Maize and *bajra*	22.00	...	22.00
Bullocks	40	Sweet Sudan, Napier	30.50	...	30.50
Suckling calves	200	Oats	22.50	52.25	74.75
		Cowpeas	4.00	17.00	22.00
		Total	271.5	207.5	479.0

The grazing and fodder calendar for the Hariana cattle has been evolved by S.P. Srivastava of Bharari in consultation with Animal Production Branch of F.A.O. and C. A. Shacklady of Liverpool, England (see Table XXXVI). The feeding schedule is adjusted according to availability of feeds month by month, and on the basis of the classification of fodders given in Table XXXV.

TABLE XXXV

Classification of fodders available at Bharari (Jhansi), U. P.

Green Fodders		Dry Fodders		
Category A	Category B	Category A	Category B	Category C
Berseem	*Juar*	Oat hay	Gram straw	Wheat straw
Lucerne	Makchari (Teosinte)	Berseem hay	*Mung* straw	Barley straw
Oats	Napier grass	Lucerne hay	*Urid* straw	Paddy straw
Cowpea	Grass or *juar* silage	Cowpea hay	Pea straw	Oat straw
Moth	Para grass		*Anjan* hay	Grass hay
Guar			*Juar* hay	
Anjan				
Maize				
Guinea grass				
Maize silage				
Juar/legume mixture				
Sweet Sudan				

During the first quarter of the year, April to June, there are generally no green fodders available and it is necessary to provide either concentrates or high-quality conserved fodders, such as silage of category A (legumes). During the second quarter, a mixture of conserved and fresh mixed green fodders becomes available ; wherever maize and *bajra* can be grown economically, they can be used to replace conserved fodders. Pasture becomes available after the rains ; during August and September only the bullocks and milking cows require to be hand-fed, as grazing alone does not provide enough energy or may be far from the buildings.

The three months of the next quarter, October, November and December, have to be dealt with individually as there is a wide range in the fodder

which can be made available. The *rabi* legumes generally come in December. Different rations have, therefore, been proposed for these months, based on mixed green fodders in October, mixed hay in November, and green legumes and *kharif* legume hays during December. The fourth quarter, January to March, is when fodders of high nutritive value such as berseem and oats are available ; their dry matter and energy deficiencies may be made up by supplements of straw or hay.

TABLE XXXVI

Detailed statement of proposed rations for different classes of animals (Hariana) on a month by month basis at Bharari (S. P. Srivastava and C. A. Shacklady)

(Figures in lb.)

Class of animal	Stated requirements			Provided by ration				Recommended			
	April—June										
	D. M.	D.C.P.	S. E.		D. M.	S. E.	D.C.P.		D.M.	S. E.	D.C.P.
Growing bulls	10-12	0.85	4.8	15 lb. silage	3¾	1.7	0.15	20 lb. silage	5	2.25	0.2
				8 lb. 'A' fodder	8	2.16	0.50	5 lb. 'A' fodder	5	1.35	0.3
								2 lb. calf concentrate	2	1.28	0.37
				Total	11¾	3.86	0.65	Total	12	4.88	0.87
Stud bulls	15-18	0.85	5.2	20 lb. green 'A'	4	1.8	0.48	20 lb. silage	5	2.25	0.2
				10 lb. 'A' fodder	10	2.7	0.60	5 lb. green 'A'	1	0.45	0.1
				Total	14	4.5	1.08	9 lb. "A" fodder	9	2.43	0.54
								Total	15	5.13	0.84
									or better		
								15 lb. silage	4	1.7	0.15
								5 lb. green 'A'	1	0.45	0.10
								9 lb. 'A' fodder	9	2.43	0.54
								1 lb. maize	1	0.72	0.07
								Total	15	5.30	0.86

TABLE XXXVI (contd.)

Class of animal	Stated requirements D. M.	D.C.P.	S. E.	Provided by ration	D.M.	S. E.	D.C.P.	Recommended	D.M.	S. E.	D.C.P.
Bullocks	18-22	1.0	9.8	40 lb. silage	10	4.5	0.4	50 lb. silage	12½	5.6	0.5
				4 lb. 'A' fodder	4	1.08	0.24	4 lb. 'A' fodder	4	1.1	0.24
				4 lb. concentrate	4	2.7	0.46	4 lb. maize	4	3.0	0.28
				Total	18	8·28	1.10	Total	20½	9.7	1.02
Dry cows	15	0.45	4.5	30 lb. silage	7½	3.37	0.3	20 lb. silage	5	2.25	0.2
				4 lb. 'A' fodder	4	1.08	0.24	10 lb. Pea Straw	10	2.20	0.3
				Total	11½	4.45	0.54	Total	15	4.45	0.5
Milk cows 7 lb.	18 reckon	(0.80) 0.83	(6.0) 6.4	30 lb. silage	7½	3.37	0.3	40 lb. silage	10	4.5	0.4
				5 lb. 'A' fodder	5	1.35	0.3	5 lb. 'A' fodder	5	1.35	0.3
				1 lb. concentrate	1	0.67	0.21	1 lb. concentrate	1	0.67	0.21
				Total	13½	5.39	0.81	Total	16	6.52	0.91
Milk cows 12 lb.	18 reckon	(1.05) (1.1)	(8.1) 7.8		16½	7.0	1.3	50 lb. silage	12½	5.6	0.5
								5 lb. 'A' fodder	5	1.35	0.3
								1½ lb. concentrate	1½	1.00	0.3
								Total	19	7.95	1.1

(*July*)

	Provided by ration				Recommended			
Growing bulls	20 lb. "A" green	4	1.8	0.48	10 lb. "A" green	2	0.90	0.24
	8 lb. "A" fodder	8	2.16	0.48	8 lb. "A" fodder	8	2.16	0.48
	Total	12	3.96	0.96	2 lb. maize	2	1.44	0.14
					Total	12	4.50	0.86

TABLE XXXVI (contd.)

Class of animal	Provided by ration				Recommended			
		D. M.	S. E.	D.C.P.		D. M.	S. E.	D.C.P.
Stud bulls	say Grazing (40 lb.)	8	3.60	0.56				
	10 lb. "A" green	2	0.90	0.24				
	4 lb. Oat hay	4	1.08	0.19				
	Total	14	5.58	1.09				
Bullocks	40 lb. maize	8	4.32	0.54	50 lb. maize	10	5.4	0.68
	10 lb. oat hay	10	2.70	0.48	8 lb. oat hay	8	2.16	0.38
	4 lb. concentrate	4	2.66	0.46	3 lb. maize	3	2.25	0.21
	Total	22	9.68	1.484	Total	21	9.81	1.27
Dry cows	30 lb. mixed fodder	7.5	3.38	0.45	Not recommended before calving			
	10 lb. "C" fodder	10.0	1.8	0.05				
	Total	17.5	5.18	0.50				
Milk cows 7 lb.	Grazing 50 lb. mixed fodder	12.5	5.6	0.75	Grazing need only supply some bulk as requirement already covered			
	1 lb. concentrate	1	0.67	0.21				
	Grazing		6.27	0.96				
Milk cows 12 lb.	40 lb. green feed 'A'	8-10	3.6	0.96	50 lb. mixed fodder	12.5	5.6	0.75
	5 lb. oat hay	5	1.35	0.24	9 lb. oat hay	9	2.43	0.43
	3 lb. concentrates	3	2.00	0.63	Total	21.5	8.03	1.18
	Total	16-18	6.95	1.83				

August and September

Growing bulls	Grazing (40-50 lb.)	8-10	4.0	0.81	Assuming 40-50 lb. of good quality grazing available, ration stands
	8 lb. green feed	2	0.8	0.1	
Stud bulls	As in July				

Table XXXVI (contd.)

Class of animal	Provided by ration				Recommended			
		D. M.	S. E.	D.C.P.		D.M.	S.E.	D.C.P.
Bullocks	40 lb. mixed fodder	8-10	4.0	0.54	50 lb. mixed fodder	10-12	4.95	0.66
	10 lb. oat hay	10	2.7	0.48	9 lb. oat hay	9	2.43	0.43
	4 lb. concentrate	4	2.6	0.46	3½ lb. maize	3	2.6	0.22
	Total	22-24	9.3	1·48	Total	22-24	9.98	1.31
Dry cows	Grazing (50-60 lb.)	10-12	4.9	0.9	Assuming 50-60 lb. grazing available, ration appears adequate			
	10 lb. green fodder	2-2½	0.9	0.24				
	Total	12-14½	5.8	1.14				
Milk cows 7 lb.	Grazing 10 lb. mixed fodder	2	0.9	0.12	25 lb. grazing	5-6	2.4	0.45
	1 lb. concentrate	1	0.7	0.21	12 lb. oat hay	12	3.2	0.57
	Grazing must supply 4.8 lb. S.E., 0.5 lb. D. C. P., i. e. about 50 lb. of pasture				1½ lb. maize	1½	1.0	0.10
						18½ 19½	6.6	1.12
Milk cows 12 lb.	Grazing 10 lb. mixed fodder	2	0.9	0.12	As above plus 2 lb. maize			
	7 lb. concentrate	7	4.7	1.4				
	Total	9	5.6	1.52				
	Grazing must supply 2.2 lb. S.E , i.e. 25 lb. grazing							
October								
Growing bulls	30 lb. mixed fodder	7	3.15	0.42	40 lb. mixed fodder	10	4.5	0.6
	2 lb. concentrate	2	1.3	0.24	2 lb. concentrate	2	1.3	0.24
	Total	9	4.45	0.66	Total	12	5.8	0.84
Stud bulls	60 lb. mixed fodder	14	6.3	0.84				
Bullocks	40 lb. mixed fodder	10	4.5	0.6				
	30 lb. cowpeas	6	2.7	0.72				
	4 lb. concentrate	4	2.7	0.46	Maize (3½ lb.) could replace concentrates			
	Total	20	9.9	1.78				

Table XXXVI (contd.)

Class of animal	Provided by Ration	D. M.	S. E.	D. C. P.	Recommended	D. M.	S. E.	D. C. P.
Dry cows	30 lb. mixed fodder	7½	3.4	0.45	Using lowest nutritive value for "C" dry fodder			
	7½ lb. "C" fodder dry	7½	1.27	0.01				
	Total	15	4.67	0.46				
Milk cows 7 lb.	10 lb. mixed *Juar* hay	10	2.2	0.2	15 lb. mixed *Juar* hay	15	3.3	0.3
	30 lb. green feed	6-7½	2.4	0.36	30 lb. green feed	6	2.4	0.36
	1 lb. concentrate	1	0.67	0.21	1 lb. concentrate	1	0.67	0.21
	Total	17	5.27	0.77	Total	22	6.37	0.87
	If green feed is category A.		5.57	1.25				
Milk cows 12 lb.	10 lb. mixed *Juar* hay	10	2.2	0.2	15 lb. mixed *Juar* hay	15	3.3	0.3
	30 lb. green feed	6	2.4	0.36	30 lb. green feed	6	2.4	0.36
	6 lb. concentrate	6	3.9	1.28	3½ lb. concentrate	3½	2.3	0.70
	Total	22	8.5	1.84	Total	24	8.0	1.36

November

Growing bulls	20 lb. "A" green	4	1.2	0.48	25 lb. "A" green	5	2.25	0.60
	5 lb. cowpea hay	5	1.35	0.30	5 lb. cowpea hay	5	1.35	0.30
	1 lb. concentrate	1	0.67	0.21	1¾ lb. maize	1¾	1.31	0.1
	Total	10	3.82	0.99	Total	12	4.91	1.0
Stud bulls	20 lb. *Juar* hay	20	4.4	0.2	15 lb. *Juar* hay	15	3.3	0.15
	2½ lb. concentrate	2½	1.6	0.53	3½ lb. concentrate	3½	2.3	0.74
	Total	22½	6.0	0.73	Total	18½	5.6	0.89

TABLE XXXVI (contd.)

Class of animal	Provided by ration	D. M.	S. E.	D.C.P.	Recommended	D. M.	S. E.	D.C.P.
Bullocks	15 lb. mixed *Juar* hay	15	3.3	0.30	Add 3½ lb. maize			
	5 lb. cowpea hay	5	1.35	0.30				
	4 lb. concentrates	4	2.66	0.46				
	Total	24	7.31	1.06				
Dry cows	10 lb. mixed *Juar* hay	10	2.2	0.2				
	30 lb. green feed	6-7.5	2.8	0.42				
	Total	16-17½	5.0	0.62				
Milk cows 7 lb.	As in October							
Milk cows 12 lb.	As in October							
				December				
Growing bulls	30 lb. berseem	6	2.7	.72	Add 1 lb. maize			
	7 lb. mixed *Juar* hay	7	1.52	.14				
	Total	13	4.22	.86				
Stud bulls	40 lb. berseem	8	3.6	.96				
	10 lb. *Juar* hay	10	2.2	.1				
	Total	18	5.8	1.06				
Bullocks	As November							

TABLE XXXVI—(contd.)

Class of animal	Provided by ration	D. M.	S. E.	D.C.P.	Recommended	D. M.	S. E.	D.C.P.
Dry cows								
	10 lb. mixed *Juar* hay	10	2.2	0.2				
	30 lb. green feed	6-7½	3.15	0.28				
	Total		5.35	0.48				
Milk cows 7 lb.	12 lb. mixed *Juar* hay	12	2.64	0.24	10 lb. mixed *Juar* hay	10	2.2	0.2
	30 lb. berseem	6	2.7	0.72	30 lb. berseem	6	2.7	0.72
	Total		5.34	0.96	2 lb. maize		1.5	0.15
					Total	16	6.4	1.07
Milk cows 12 lb.	50 lb. berseem	10	4.5	1.2	40 lb. berseem	8	3.6	0.96
	10 lb. grass hay	10	2.5	0.2	12 lb. grass hay	12	3.0	0.24
	1 lb. concentrate		0.67	0.21	1¾ lb. maize		1.25	0.12
	Total		7.67	1.61	Total		7.85	1.32
				January and March				
Growing bulls	40 lb. berseem & oats	8	3.6	0.8				
	5 lb. straw	5	1.0					
	Total	13	4.6	0.8				
	Depends on type of straw e. g. wheat, oats, barley and rice probably not good enough.							
Stud bulls	40 lb. berseem & oats	8	3.6	0.8				
	10 lb. straw or hay	10	2.0					
	See above							
Bullocks	30 lb. berseem	6	2.7	0.72	40 lb. berseem	8	3.6	0.8
	10 lb. grass hay	10	2.5	0.20	15 lb. hay	15	3.75	0.3
	4 lb. concentrate	4	2.6	0.46	3½ lb. maize	3½	2.60	0.24
	Total	19	7.8	1.38	Total	26½	9.95	1.34

TABLE XXXVI—(contd.)

Class of animal	Provided by ration	D.M.	S. E.	D.C.P.	Recommended	D. M.	S. E.	D.C.P.
Dry cows	30 lb. Berseem	6	2.7	0.72	Make straw up to 10 lb.			
	8 lb. Straw	8	1.6					
	Total	14	4.3					
Milk cows 7 lb.	As December							
Milk cows 12 lb.	As December							

TABLE XXXVII

Assumed yields and costs of different fodders at Bharari (1953)

Fodder	Yield per acre in maunds	Cost per maund Rs.	As.
Berseem	300	0	12
Chari	250	1	0
Mixed fodder	250	1	0
Maize (early)	50	1	0
Maize and *bajra* in season	100	1	0
Oats	200	1	0
Cowpea	125	0	12
Sweet Sudan, *anjan*, etc.	200	0	12
Legume hay (berseem, etc.)	75	4	8
Oat hay	50	4	8
Cereal straw and grass hay	...	3	0
Silage	2/3rd of green weight	1	8

Bishan Mansingh, Fatehpur, U. P. (Bilanda Farm)

Mr. Mansingh has developed his farm on 340 acres of *usar* or alkaline land classified as *Gair munkin*, impossible for crop cultivation. (For method of reclamation see Chapter XIII). About 20 acres are occupied by tanks and *bundhies*, 50 acres are now under paddy, 20 acres under cereal crops, 20 acres under fruit trees and the rest is covered by trees such as *babul* (*Acacia arabica*), *dhak* (*Butea monosperma*), seed-*ber* and grafted *ber* (*Zizyphus jujuba*), *sheesham* (*Dalbergia sissoo*), *nim* (*Azadirachta indica*), *mahua* (*Bassia latifolia*), etc. with an understorey of indigenous grasses and perennial weeds. When these are dry, they are used for thatch. After cutting at the end of November regrowth develops soon and provides a grazing ground for six months in the year on the ranch system for the herd of 80 cattle. Only working cattle are stall-fed to some extent with silage made in *kutcha* pits from indigenous grasses and weeds. As a result of the conservation of rain water and rotational grazing, superior grasses are steadily replacing the coarse grasses and weeds, and slowly covering bare patches of the land. Dairy farming cannot be practised under these conditions and improved breeding only is followed. All male calves are sold when one year old, the females being retained. It is cheaper and safer to purchase working cattle than to rear them Bulls supplied by the Government are maintained (Hissar), and replaced about every 5 years to prevent inbreeding. For the home milk requirements, cows and buffaloes in calf are brought from the stock farm one or two months before calving, and fed properly until they are sent back to the grazing farm about three months after calving, to be replaced by new ones. On the grazing farm, all the milk is consumed by the calves. The grazing animals eat the fallen *babul* pods as a concentrate for nearly two months each year, from mid-March to mid-May. Otherwise grazing is the only source of fodder. The grazing grounds of indigenous grasses on marginal lands have a carrying capacity of one cow per three acres. The period, April to June, is the most difficult ; in April, village cattle obtain some feed on cereal stubbles, but in the stock farm at Bilanda, Fatehpur, they have to rely on new shoots of *kans* and other grasses. During this period and also during the winter if there are continuous rains, the cattle lose condition, but recover rapidly when new growth appears after the first heavy showers of the monsoon.

Allahabad Agricultural Institute

The type of livestock kept at this Institute include dairy cattle, sheep, goats, pigs and poultry. No grazing lands are allotted to any of the bovine

animals. All livestock in the Institute, apart from sheep and goats, are stall-fed. The sheep and goats are allowed to graze to a limited extent on the campus of the Institute and on the harvested fields.

TABLE XXXVIII

Acreage (irrigated and dry) devoted to production of home-grown fodders in the year 1951-52

Fodders	Acreage	Production in maunds
Non-irrigated :		
Maize	20.0	4,000
Cowpeas	41.4	8,280
Juar	88.73	20,000
Irrigated :		
Napier grass	15.95	28,700
Para grass	0.3	150
Lucerne	6.0	1,100
Oats	10.5	3,160
Berseem	3.0	540
Total	185.88	65,000

The total acreage of crop land onthe Agricultural Institute Farm is 435. The only period when there is any difficulty in providing green fodder for the livestock is during May, June and July when high-quality green fodders are not available in adequate amounts. They are substituted by good-quality silage and green fodder obtained from irrigated Guinea and Napier grasses. Lucerne and berseem are fed to sheep, goats, calves and pigs, but not to the cows.

TABLE XXXIX

Fodder calendar at Allahabad Institute, April 1951 to March 1952

Months	Green feeds
1951 April	Berseem
	Green gram
	Green oats
	Para grass
	Lucerne
	Sunflower
May	Lucerne
	Berseem
	Green grass
	Broccoli (weed)
June	Lucerne
	Para grass
July	Maize fodder
	Mixed grasses
August	Cowpea vines
	Maize fodder
	Sugarcane tops
September	Napier grass
	Para grass
	Mung vines
	Live grass

TABLE XXXIX—(Contd.)

Fodder calendar at Allahabad Institute, April 1951 to March 1952

Months	Green feeds
1951 (contd.) October	Cowpeas
	Maize
	Napier grass
November	Cowpeas
	Bajra
	Lucerne
December	Cowpeas
	Lucerne
	Oats
1952 January	Lucerne
	Oats
	Sugarcane leaves
	Para grass
	Berseem
	Sunflower
February	Sugarcane leaves
	Lucerne
	Oats
	Napier grass
	Sunflower
	Barley

TABLE XXXIX—(Contd.)

Fodder calendar at Allahabad Institute, April 1951 to March 1952

Months	Green feeds
1952 (contd.) February (contd.)	Berseem
	Pea vines
March	Oats
	Lucerne
	Berseem
	Napier grass
	Maize fodder
	Para grass
	Sunflower

In addition, silage was fed in all months except July, August and September, 1951. Silage is not fed to sheep, goats, pigs, and calves below six months of age. The silage is made from *juar*, Napier grass, maize and *bajra*. Weeds and other grasses, such as *doob*, are available and are fed. Goats, sheep, pigs and poultry receive berseem, lucerne weeds, and grasses only.

The main constituents of the grain and concentrate ration are wheat bran and *arhar chuni*, which are available throughout the year ; mustard cake and *mutter* husk are sometimes not available in the local markets in the quantities desired ; they are then substituted by linseed cake, groundnut cake, gram husk, and *kassari*, whichever is available and cheap in the markets. The last four items are rather scarce commodities and are not available throughout the year in the Allahabad markets.

TABLE XL

Grain and concentrate rations, Agricultural Institute, Allahabad

Concentrates	Parts
All livestock except poultry	
Mustard cake	27
Wheat bran	27
Arhar chuni	27
Mutter husk	19
Mineral mixture	5 per cent of the concentrate mixture
Poultry	
Juar grains	36
Bajra grains	36
Wheat bran	14
Blood meal	14
Mineral mixture	5 per cent of the concentrate mixture

The constitution of the mineral mixture, of which 5 per cent is added to the grain and concentrate mixture fed to all livestock except poultry, is given in Table XLI.

Ten pounds of bonemeal and 1 oz. of manganese chloride constitute the mineral mixture for poultry mash. The other mineral constituents are not included for poultry. Codliver oil is added to the grain and concentrate mixture including the poultry mash at 1 *chhatak* (2 oz.) per maund. The mineral mixture was specially designed at the Allahabad Agricultural Institute and has prevented many of the common diseases which arise because of nutritional mineral deficiencies.

TABLE XLI

Formula of mineral mixture at Agricultural Institute, Allahabad

Mineral mixture	Weight
Sodium chloride	1280 lb.
Bonemeal	1280 lb.
Sodium iodide	200 grm.
Cobalt chloride	200 grm.
Magnesium sulphate	10 lb.
Copper sulphate	500 grm.
Manganese chloride	500 grm.
Ferrous sulphate	1000 grm.

Central Livestock Research and Breeding Farm, Haringhata

This farm is 37 miles north of Calcutta in the District of Nadia, West Bengal. The natural rainfall varies from 36 to 54 inches for the three years for which records are available. As irrigation was not possible until the beginning of 1953-54, cultivation of fodder crops depended entirely on the seasonal rainfall and the desired programme could not always be achieved.

The yields of the main *kharif* crops are fairly good. Gram and peas are the only reliable *rabi* crops under rain-fed conditions. The absence of rain during the 1953-54 sowing season contributed to the poor acreage of gram and peas. Berseem was grown with promising results experimentally on 18.5 acres in 1952-53, utilizing liquid manure and wash-water from cowsheds. When water became available in 1953 from a tube well, the berseem area was extended to 79 acres ; the performance of the 1953-54 crop indicated that berseem is likely to become one of the best *rabi* crops under irrigation in West Bengal. Yields were higher from berseem following berseem than from berseem following natural grass.

TABLE XLII

Area under fodder crops at Haringhata in 1952-53 and 1953-54 (in acres)

Season	Crop	1952-53	1953-54
Kharif	Maize and cowpea	221	299
	Juar and cowpea	397	209
	Cowpea	218	176
	Kalai	43	3
	Total	879	687
Rabi	Berseem	19	79
	Oats	14	100
	Peas	177	33
	Mung	9	...
	Gram	160	71
	Rape	15	...
	Juar and maize	42	...
	Total	436	283
	Perennial grass (Napier)	31	
	Total fodder acreage	1346	970

TABLE XLIII

Types and average number of livestock at Haringhata

Type of livestock	Year	Hariana	Tharparkar	Sahiwal	Murrah	Total
Milch animals	1952-53	261	9	5	30	305
	1953-54	275	7	7	39	328
Dry cows	1952-53	99	6	2	18	125
	1953-54	111	4	4	15	134
Young stock of various ages	1952-53	733	21	10	96	860
	1953-54	869	19	21	116	1025
Bulls	1952-53	4	2	2	2	10
	1953-54	4	2	2	3	11
Bullocks	1952-53	9	...	...	10	19
	1953-54	10	...	...	14	24

TABLE XLIV

Daily rations at Haringhata

Livestock	Fodder *ad lib.* and concentrates as below
Buffaloes and cows in milk	50 per cent of the milk yield
Dry buffaloes and cows	3 lb. per head up to 7 months of pregnancy and
	3 lb. above 7 months
Calves	3 lb. per head
Bulls	4 lb. of gram per head and
	2 lb. of other concentrate mixture
Bullocks during working period	8 lb. per head

TABLE XLV

Composition of ration (green roughages and concentrates) at Central Livestock Research and Breeding Farm, Haringhata

Fodder	April 1953	May 1953	June 1953	July 1953	August 1953	September 1953	October 1953	November 1953	December 1953	January 1954	February 1954	March 1954
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Dry :												
Paddy straw	27.40	41.66	11.26	0.20	—	—	—	—	—	1.40	6.44	20.91
Wheat straw	1.64	—	—	—	—	—	—	—	—	—	—	—
Wheat *bhusa*	—	0.21	0.51	—	—	—	—	—	—	—	—	—
Field grass :												
Setaria glauca, *Brachiaria distachya*, *Saccolepis indica*	26.07	50.22	35.64	21.28	0.66	21.9	17.16	18.44	20.47	21.20	23.38	20.52
Water grass :												
Hymenachne pseudo-interrupta, *Leersia hexandra*, *Echinochloa crus-galli*	—	—	—	—	—	—	8.64	2.77	6.78	24.56	13.38	—
Green fodder :												
Berseem	0.90	—	—	—	—	—	—	—	2.92	24.12	36 26	44.28

TABLE XLV—(*contd.*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Napier grass	—	—	8.55	1.72	0.18	3.87	—	2.52	—	—	—	—
Juar, *Juar* and cowpea	5.53	7.40	44.04	6.80	—45.66	87.20	71.78	86.63	22.84	0.38	—	0.54
Maize and cowpea	26.27	—	—	69.20	—36.32	4.05	—	—	—	—	—	—
Cowpea	1.64	0.5	—	0.33	17.18	2.94	2.42	—	—	—	—	—
Pea	—	—	—	—	—	—	—	—	3.48	1.7	—	—
Oats	—	—	—	—	—	—	—	—	—	6.32	15.46	6.05
Gram	—	—	—	—	—	—	—	—	—	5.66	4.89	15.30
Silage: *Juar* and cowpea, or maize and cowpea	—	—	—	—	—	—	—	7.64	43.51	14.65	—	—
Concentrates :												
Gram	32.42	31.48	19.06	8.40	32.62	32.56	32.56	32.48	31.80	25.32	28.14	17.60
Linseed cake	16.74	17.07	20.38	32.40	17.92	16.80	16.79	24.22	33.77	36.86	21.09	20.98
Groundnut cake	16.74	17.07	20.38	22.14	15.63	16.80	16.79	9.30	—	—	12.80	16.53
Wheat grain	31.81	32.04	38.17	44.64	31.81	31.82	31.83	31.99	38.48	35.23	34.35	42.86
Salt	2.01	2.01	1.92	1.00	1.02	1.02	1.04	1.84	0.67	—	1.48	1.04
Khesari	0.89	—	—	—	—	—	—	—	—	—	—	—
Matar (Pea)	—	0.33	—	—	—	—	—	—	—	0.68	2.32	—
Kalai	—	—	—	0.03	—	—	—	—	—	—	—	—
Mineral mixture	—	—	0.10	0.99	0.98	0.99	0.99	0.17	1.34	1.90	0.46	0.99

The natural grasses are a real asset and are fully utilized ; they contributed 22 and 24 per cent of the total fodder supplied in 1952-53 and 1953-54 respectively. *Setaria glauca*, *Brachiaria distachya* and *Saccolepis* spp. predominate on marshy areas which do not become stagnant during the monsoon ; where water does become stagnant, species such as *Hymenachne pseudo-interrupta*, *Leersia hexandra* and *Echinochloa crus-galli* predominate. Grasses in dry areas are mown when possible, otherwise harvesting is done by hand.

Although the animals are primarily stall-fed, they are allowed to graze whenever possible. The milch animals graze for four or five hours per day on areas from which a crop has been cut, or where natural grasses are available. As they are more accustomed to being stall-fed, the amount of fodder they obtain from grazing is negligible. Young stock are grazed for seven to eight hours per day. Grazing during the wet months is not possible.

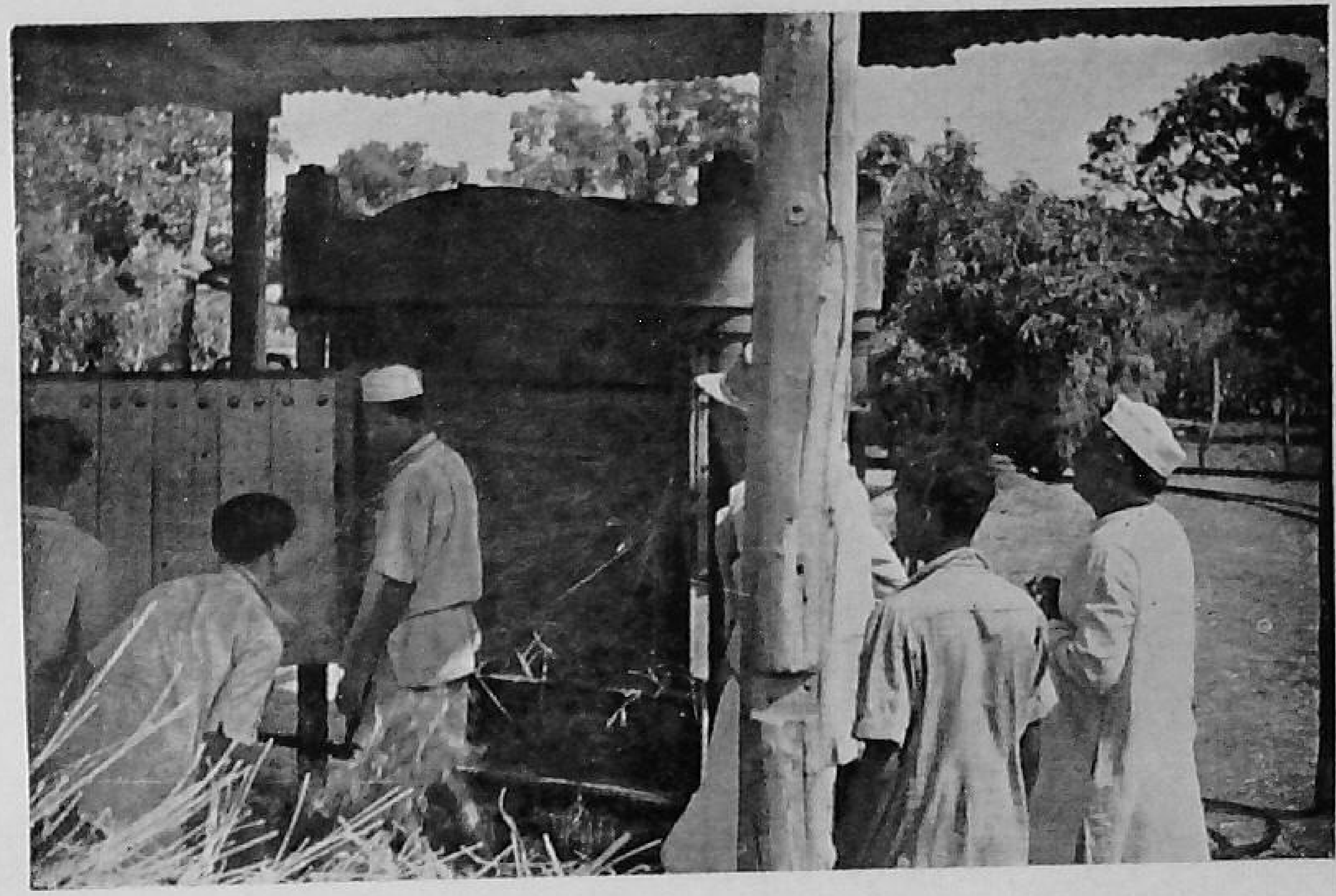
As the yield of natural herbage or from stubbles is so variable, it is not possible to state their carrying capacity. The control of livestock by electric fences on crops like oats and cowpeas has been successful and is to be extended to all grazing areas and crops.

So long as fodder supply depended on rainfall, the difficult period was during the *rabi* months of December, January, April and May. The production of fodder from non-irrigated crops, such as gram and peas, suffers when there are not adequate showers of rain during their growth, and the natural grasses suffer likewise. Silage is made on a fairly large scale to supply succulent feeds during scarcity periods.

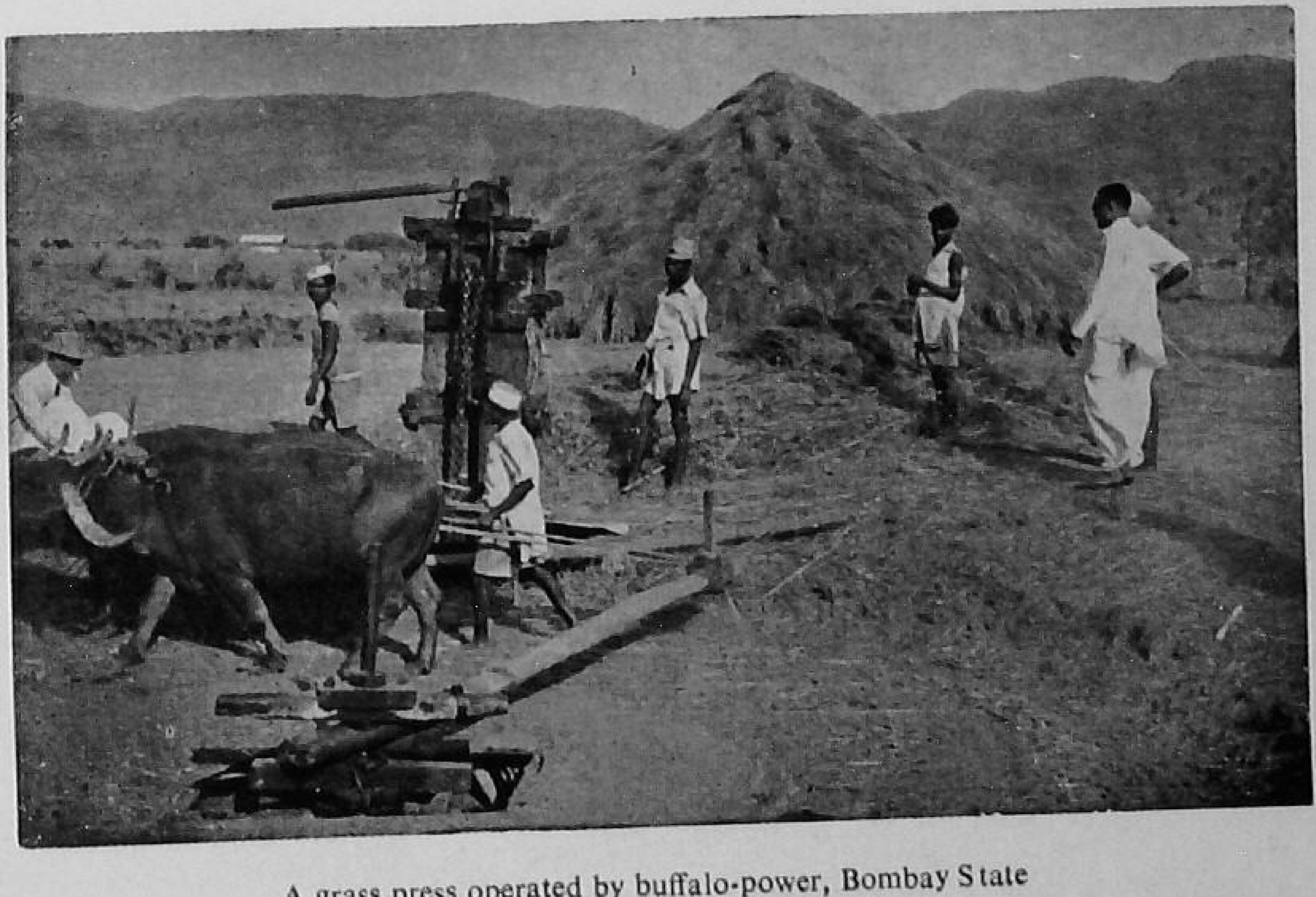
TABLE XLVI

Cost of production of fodder (including harvesting and loading) during 1952-53 at Haringhata

Crop	Rupees per maund
Juar	0.53
Maize	1.01
Cowpea	0.74
Kalai	0.73
Berseem	1.06
Natural grasses	0.34



A press used in the districts which supply Greater Bombay with grass straw
Photo : R. O. Whyte



A grass press operated by buffalo-power, Bombay State
Photo : R. O. Whyte

Aarey Milk Colony, Bombay

The Colony has at present (February 1953) about 13,000 animals comprising mostly buffaloes of four different breeds, viz. Murrah, Mehsana, Jafrabadi and Surti. Only 150 Kankrej and Gir cows are kept.

The stock receive jungle hay, Para grass and green jungle grass as the main items of their roughage ration. Small quantities of *juar* cultivated during the monsoon are also available. The buffaloes receive about 15 to 18 lb. of hay and 10 lb. of Para grass per day, but the proportion varies according to the availability of green grass. Furthermore, a daily ration of about 13 lb. of grain and concentrates, soaked in water for several hours, is fed at both milking times.

TABLE XLVII

Composition of grain and concentrate ration

Ration	Weight (in lb.)
Tur coarse meal (*chuni*)	3
Gram *chuni*	1.25
Guar	1
Cottonseed	2.25
Groundnut cake	1.25
Til cake (Sesame)	1.25
Copra cake	0.50
Wheat bran	1
Ghala (mixture of bran and husk of legume grains)	1.25
Others	0.25
Total per day	13.00

No land is available for grazing. The Para grass is grown as a perennial on about 150 acres which are irrigated by the wash-water from the cattle sheds. The average wet yield is 200,000 lb. per acre without extra manuring. In addition, 95 acres are irrigated with fresh water from the Pawai Lake and receive 15 tons of farmyard manure every year. Here, a wet yield of about 115,000 to 125,000 lb.

per acre can be obtained. About 80 acres of *juar* are cultivated during the monsoon. Jungle grass is obtained from about 2,000 acres of unbroken land.

Under normal conditions, no difficulty is experienced in maintaining a uniform level of nutrition throughout the year, chiefly because all the necessary feeds are available from the neighbourhood.

Bombay Gow-Rakshak Mandali

On the farm maintained by the 'Cow-Preservation Society' (*Gow-Rakshak Mandali*), 35 acres are under irrigation and 55 acres are dry.

TABLE XLVIII

Acreage of fodder crops on Kandivli and Betegaon Cattle Breeding Farms, Bombay

Fodder crops	Acres
Irrigated :	
Para grass	5
Lucerne	9
Berseem	9
Juar	8
Choli	1
Val	1
Carrots	2
Dryland :	
Tur	15
Juar	40

The ration for the herd of 600 pure-bred Gir cows, bulls and bullocks is composed of hay, green fodder and concentrates. Green grass is cut in October each year and made into hay. The common grasses are *Ischaemum rugosum, Pseudanthistiria heteroclita, Iseilema wightii,* and *Dichanthium annulatum.* The yield is 2,000 maunds per acre, but with the improvement and development of the grassland by tillage and manuring, it is hoped to increase the yield by 75 to 100

per cent. The annual production of hay at the Kandivli and Betegaon Farms s 18 lakh lb.

The crops used for green fodder on these farms are indicated in Table XLVIII above.

For concentrates, crushed *tur, guar* and *urid* are fed in addition to crushed cottonseed and groundnut cakes in the following daily basic ration in pounds per animal :

Cottonseed	1
Crushed *tur* and *guar*	1
Oilcake	½
Husks	1½
Total	4 with 1 oz. salt.

In addition, for every pound of milk, ½ lb. of the mixture is given to each milking animal from July to October. Para grass is given from November to May with fodders such as lucerne, berseem, carrots, *juar* and *choli*. The animals are stall-fed but are sent for exercise and grazing twice a day in 100 acres set apart for this purpose ; for full grazing two acres per animal are required. April and May are the difficult periods due to shortage of water in the wells.

Telankheri Government Dairy Farm, Madhya Pradesh

Sahiwal cows and Murrah and Nagpuri buffaloes are maintained on this farm. Only 300 acres are available for grazing at an optimal carrying capacity of one animal per two acres for five months of the year only, July to November. The soil is light in character. Twenty acres of irrigated land and 65 acres of dry-land are devoted to fodder production. The green fodders grown include *juar*, sunflower, maize, Guinea grass and berseem. The dry fodders available include *juar kadbi*, grass hay, paddy straw and wheat *bhusa*. Silage is made from *juar*, maize and green grass. The pasture and fodder calendar is shown in Table XLIX.

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TABLE XLIX

Pasture and fodder calendar at Telankheri

Months	Milch stock	Dry stock
April	Berseem, silage and dry grass	Grass hay and *kadbi* (*juar*) and silage
May	Green maize, sunflower and *juar* silage, grass hay	Grass hay and *kadbi* (*juar*) and silage
June	Green maize and *juar* silage, grass hay	Grass hay and *kadbi*((*juar*) and silage
July	Green maize and *juar*, grass hay and *kadbi*	Green grazing and grass hay
August and September	Green grazing, *juar*, maize, sunflower	Green grazing and green hay
October and November	Green *juar* and green grass	Grazing and green grass
December	Berseem and green grass	Grazing and green grass
January to March	Berseem hay, *kadbi* (*juar*)	Berseem and grass hay

The grain and concentrate ration fed to the milch and dry stock is adjusted according to availability and cost ; proportions are generally as shown in Table L.

TABLE L.

Percentage composition of grain and concentrate ration at Telankheri

Grain and concentrates	Milch animals and down calvers	Dry stock
Groundnut cake	50	50
Tur chuni	15	
Cottonseed/husk	10	
Wheat bran	15	
Rice bran	10	50

Common salt added at the rate of 2 oz. per head per day.

Cows receive 40 to 50 per cent of this mixture, inclusive of maintenance ration, throughout the year, buffaloes 50 to 60 per cent according to the quantity and quality of green fodder available. Dry cows receive a concentrate mixture at 6 lb. for 1½ months between calving ; dry buffaloes at 5 lb.

It is difficult to maintain the green fodder supply in the period April to mid-July and again in October and November. A uniform level of nutrition can be maintained if water is plentiful and perennial grass is grown on a larger area.

Indian Dairy Research Institute, Bangalore

The livestock at the Institute are as follows :

Livestock		In milk	Dry	Total
Cows :	Crossbred	53	17	70
	Sindhi	34	21	55
	Tharparkar	6	1	7
	Gir	20	8	28
	Total	113	47	160
Buffalo :		7	11	18
		Female	Male	
Young stock	Sindhi	29	22	
	Gir	21	13	
	Tharparkar	5	2	
	Crossbred	65	8	
	Buffalo	15	3	
	Total	135	48	
Bulls :	Cow	11		
	Buffalo	2		
	Work bullocks	43		
	Ponies	5		
	Foals	5		

TABLE LI

Composition of ration in lb. fed in 1952 at the Indian Dairy Research Institute, Bangalore

Name of crop	January	February	March	April	May	June	July	August	September	October	November	December
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Green Fodder (all crops are produced at the farm)												
Lucerne	1240	1160	1360	1210	1545	1500	1400	1390	1690	1550	2170	12409
Napier grass	6120	8100	27160	11480	46120	46830	63200	36140	42400	26680	70060	20200
Guinea grass	73130	30600	44060	64160	98640	123540	13700	126320	140720	120280	111140	54680
Rhodes grass	7290	13700	13000	19740	12920	20720	16660	17050	16540	94910	19410	6550
Green *juar*	36000	—	—	21030	18150	—	68700	27000	341460	406570	275240	137560
Mixed grasses	10150	9200	24750	26710	28610	47520	48300	82270	39310	30030	90900	129700
Juar silage†	302650	264882	—	—	—	—	—	—	—	—	—	—
Woolly finger grass s	—	—	—	2920	6260	9410	3960	1900	5330	5160	320	6300
B. Roughages												
Ragi straw‡	—	16125	70345	84870	77970	83540	63740	71375	9995	6200	6000	2825
Kulthi straw**	—	2350	1550	—	—	—	—	—	—	—	—	—
*Juar kadbi***	27600	29600	8560	27050	24900	9300	—	—	—	—	—	—
Doob hay*	—	—	—	—	1792	2880	1928	6112	7200	4950	4500	63440
Avare straw**	—	—	—	—	1000	—	—	—	—	—	—	—

C. Concentrates

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Oats	—	—	—	7444	9958	2965	—	11517	10833	9669	10953	12153
Groundnut cake*	9964	9293	10869	11612	9543	10628	11568	12674	12170	12858	12614	16384
Wheat bran**	9041	8500	9401	9684	11364	10095	9538	12258	14413	15330	10585	11857
Gram (crushed)*	18351	17456	19384	12309	10560	17291	19871	9345	9138	12266	10706	11596
Gram (husk)*	6993	6484	7501	7873	9387	8440	7796	6367	3841	4345	8581	9183
Common salt*	924	875	976	1025	1035	978	1028	1106	1057	1043	1046	1074
Mineral mixture*	—	—	74	57	—	—	—	—	—	—	—	164
Jaggery*	23	—	41	44	52	18	36	41	44	54	42	89
*Kulthi***	—	—	48	270	310	334	710	2309	2062	260	240	248

* Purchased

** Produced on the farm.

† In addition to the quantities of *juar* issued for the daily ration of the cattle, a surplus of 2,02,200 lb. during September, 1952, 5,14,670 lb. during October, 1952 and 4,04,520 lb. of *juar* during November, 1952 (total 11,21,390 lb.) have been conserved in the form of silage.

‡ The total quantity of ragi straw issued for ration during the year is 4,92,985 lb. Out of this quantity 3,80,155 lb. is purchased from outside sources and the balance of 1,12,830 lb. has been produced on the farm land.

Good permanent grazing in the form of a nutritious close-cropped grass/legume sward is not available. There are 165 acres of submarginal and unculti-vable land on one of the farms for dry and young stock ; about 140 head of cattle graze on the rough natural grazing, a mixture of coarse and fine species of low carrying capacity.

The average annual rainfall of the area is 35 inches, confined to the period, June to November. Cyclonic showers mark the beginning and end of the rainy reasons. The onset of summer is preceded by a period of cold weather between December and February. During the rainy season, the grazing areas develop quite a fair stand of grass which grows away from the stock during the height of the rains.

The following is the seasonal picture :

July/August	Grazing adequate
September/October	Growth exceeds requirements
November/December	Grazing adequate
January/February	Grazing coarse
March/June	Grazing very poor or non-existent

TABLE LII

Acreage devoted to fodder cultivation at Indian Dairy Research Institute, Bangalore

	Bangalore Farm	Bomman-pally Farm	Agram Dry and Young stock Farm
Irrigated land	21.5	...	12.0
Dry land (*Barani*) Farm agency	51.5	15.0	151.74
Dry land (*Barani*) cultivated under *battai* system. The cultivator is to provide all the labour, manure, seed, etc. and the lessee to surrender to the Institute 1/3 of the grain produced and 1/2 of the straw	...	20.0	60.0

The entire green fodder needs of the Institute herd are met from home production. Of the dry fodders, 380,155 lb. of ragi straw and 138,950 lb. of *doob* hay were purchased during the period under review, the balance grown on the farm. The irrigated land in Table LII is devoted to the cultivation of the perennial fodder grasses listed in Table LI, which yield some five to eight successive cuts throughout the year. The dry land is cultivated to a fodder variety of *juar* grown during the monsoon months, June to November ; this crop is available for use from September to December. As this is the period when surplus grass is available from the irrigated land, the surplus *juar* is made into silage.

A slight seasonal fluctuation in supply of fodder occurred during the months of March and July, 1952, but it did not affect the nutritional level of the animals. (See Table LI)

Livestock Farm and Research Station, Hessarghatta, Mysore

The following types of livestock are kept :

Sindhi cattle

Murrah buffaloes

Hallikar cattle

Cross-bred cattle

Mutton-type sheep of Bannur breed

Wool-type sheep of Hassan breed

Jamnapyari X Syrian goats

Horses

The ration varies according to type of livestock, availability of green roughage and other feeds, e.g. green fodder may be Rhodes grass, Guinea grass and Giant Napier, with small quantities of lucerne ; during the dry season, this green fodder is replaced by hay and silage.

Horses. These are raised on the ranch system, and receive, in addition to grazing throughout the year, 20 lb. green grass (Rhodes) per head per day plus concentrates (Table LIII).

TABLE LIII

Concentrate ration for horses at Hessarghatta, Mysore

Concentrates	Stallions	Mares	Young stock
Oats	8 lb.	4 lb.	4 lb.
Wheat bran	4 lb.	2 lb.	1½ lb.
Common salt	2 oz.	1 oz.	1 oz.
Mineral mixture	2 oz.	1 oz.	½ oz.

The stallions kept under stall-fed conditions receive 50 lb. of green Rhodes grass per day. During the dry period, the green grass is supplemented by 15 to 20 lb. of hay.

Sheep : No concentrates are given while grazing is good, i.e. from June to January. When grazing is not available, the sheep receive 2 oz. per head of a mixture of concentrates, plus 2 lb. per head of chaffed lucerne and Rhodes grass.

Dairy Cattle : The concentrates given are rice bran, horse gram, wheat bran, gram husk, groundnut cake powder and common salt. Every milking animal receives a maintenance ration of 5 lb. concentrate mixture per day throughout the year, and an extra ration of 1 lb. concentrate mixture for every 2½ lb. of milk produced Dry cows get 2 lb. of concentrate plus 30 lb. of green fodder or 40 lb. of hay.

Green roughage in the form of Rhodes, Guinea or Giant Napier grasses is given from June to September to milking animals to supplement their grazing in the kavals. Stall-fed animals receive 20 lb. per head from September to January, unless there is ample grazing available. From February to September, the milking stock receive 30 lb. of silage and the dry herd 40 lb. of hay.

Young calves are not weaned immediately, they are allowed to suckle about 4 or 5 lb. of milk per day, and also receive gruel until two months old. Throughout the year they receive 10 lb. per head of lucerne and Rhodes grass in addition to 1 to 1½ lb. of concentrates.

The grazing season is from September to the end of January, when grass is abundant ; the carrying capacity is 5 acres per head. Rhodes, Guinea and Giant Napier grasses and lucerne are grown on 50 acres of irrigated land. On the dry

land, there are 80 acres of ragi giving about 80 tons of ragi straw; 1,000 acres are under indigenous pasture grasses yielding about 1,000 tons of grass, of which half is made into hay. There are 75 acres under *juar* for ensilage.

During the summer period from March to May, the fodder supply is difficult and a uniform level of nutrition cannot be maintained.

Cattle Breeding Farm, Ajjampur, Mysore

The livestock are Amritmahal cows, bulls, bullocks and calves.

The seasonal feeding calendar is :

January to August :	25 to 30 lb. of silage with 3 lb. concentrates for adult animals.
August to October :	40 to 50 lb. green grass without concentrates.
November to December :	25 to 30 lb. kaval hay with 2 lb. concentrates for working bullocks and milking cows.

An area reserved for mowing grass (600 acres) is fully grazed during the *munger* rains, and is then closed to grazing from August to October, when the hay crop is cut. The other kaval land is used throughout the year. The average carrying capacity is about one animal per three acres of rainfed pasture; as this is not sufficient, about 800 animals have to be sent to the jungles to graze for four months from June to September each year.

Silage is made from 150 acres of *munger dodda jola*. Only about half-an-acre of Rhodes grass is grown under irrigation for feeding the young stock throughout the year. It is proposed to irrigate five acres under Rhodes and Giant Napier grasses to feed the heifers, bullocks and cows.

During the period, March to June, it is generally difficult to maintain the animals, as there is no grazing available and they are dependent on stall-feeding. Sufficient concentrates are not available because of the increased cost at this time of the year and a restricted budget.

MILITARY FARMS

H. Q. Southern Command, R.V.F. Branch, Kirkee (Bombay)

Livestock : Friesian, cross-bred and indigenous (Sindhi, Gir, Tharparkar) cows ;
Grade buffaloes (Murrah, Nili, Mehsana) ;
Bullocks, horses, ponies and mules.

The small amount of grazing land available is grazed after the hay crop has been cut, i.e. only for a few days after the monsoon. Dry fodder is fed in the form of hay throughout the year ; if the crop could be cut earlier it would be superior quality, but havesting is not possible in September/October. There is no difficulty in maintaining the dry fodder supply throughout the year as reserves of hay are always adequate. The amount of hay fed is increased when green fodder is not available, especially during the months of April to July.

The acreage available is :

Irrigated cropland	= 510 acres
Dry cropland	= 1,480 acres
Grassland	=32,450 acres

The chief fodder crops grown are :

Kharif : *juar* and maize

Rabi : berseem, oats, barley and maize.

All the available acreage is sown in the *kharif* season, but only a small amount in the *rabi* due to lack of irrigation facilities. Small quantities of monsoon grasses such as Napier, Guinea, Rhodes and Para are also grown.

Military Farm, Dehra Dun (Uttar Pradesh)

Livestock : Grade buffaloes ,
Indian Friesian (31/32 Friesian), crossbred and grade cows
Sahiwal bulls for crossing purposes.

There is no grazing land, Acreage of fodder crops is (irrigated) berseem 25 and maize 17, and (unirrigated) oats 109 and *chari* 124. The months of May, July and November are the critical ones.

TABLE LIV

Fodder calendar, Kirkee

Month	Concentrate ration		Fodder ration: Green fodder — Class of fodder	Green fodder — Standard amount (*lb.*)	Green fodder — Proportion fed	Dry fodder (roughages) — Class of fodder	Dry fodder — Standard amount (*lb.*)	Dry fodder — Proportion fed
January			Berseem	144	1/6 to 1/3			
February	Gram	2 parts	Oats	96	1/6 to 1/3	Hay	12	5/6—2/3
March	Bran	4 parts	Silage	60	1/6	Hay	12	5/6
April	Groundnut cake	2 parts	Silage	60	1/6	Hay	12	5/6
		8						
May	When above items are not available in full, substitutes are fed as detailed below :		Silage	60	1/6	Hay	12	5/6
June			Maize	84	1/6	Hay	12	5/6
July	Gram	1 part	*Juar*	120	1/6 to 1/2	Hay	12	5/6—1/2
August	Bran	4 parts	Maize	84	1/6 to 1/2	Hay	12	5/6—2/3
September	Barley	1 part	Monsoon grass and other green grasses (September–November)	84	1/6 to 1/4	Hay	12	5/6—3/4
October	Groundnut cake	1 part						
November	Milo	1 part						
		8						
December			Berseem	144	1/6 to 1/3	Hay	12	5/6—2/3

NOTE:—Actual quantities of concentrates and fodder depend on the body weight of the cattle.

TABLE LV

Fodder calendar, Dehra Dun

Months	Dry fodder grass hay	Green fodder	Concentrate mixture
April	5/6	$\frac{1}{6}$ Berseem	Bran 3 parts Gram 1 part Oilcake 4 parts
May	1		
June	5/6	$\frac{1}{6}$ Early maize	Composition of conceutrates remains throughout the year subject to availability
July	1	—	
August	$\frac{1}{2}$	$\frac{1}{2}$ *Chari*	
September	5/12	7/12 *Chari*	
October	$\frac{1}{2}$	$\frac{1}{2}$ *Chari*	
November	1	—	
December	5/6	$\frac{1}{6}$ Berseem	
January	$\frac{1}{2}$	$\frac{5}{8}$ Oats $\frac{3}{8}$ Berseem	
February		$\frac{5}{8}$ Oats $\frac{3}{8}$ Berseem	
March	7/12	2/12 Oats $\frac{1}{6}$ Berseem	

Military Farm, Jhansi (Uttar Pradesh)

Livestock : Crossbred and grade cows ;
Stock Murrah and grade buffaloes

The areas available for fodder production are

	Acres
Grazing land	341
Grassland	500
Irrigated cultivation	60
Dryland cultivation	245

The scarcity periods for green fodder are May, June and July, and November and December. This is met to some extent by the making of silage (See Table LVI).

TABLE LVI

Fodder calendar, Jhansi

Year 1952/53	Gram	Bran	Groundnut cake and cottonseed cake	Milo	Soyabean	Barley	Scale fed	Dry fodder scale fed	Dry fodders	Green fodder scale fed	Green fodders
April	1	3	2	1	...	1	C	½	Hay and *kadbi*	½	Berseem, Napier grass and silage
May	1½	3	2½	1	...	...	B	⅔	Hay and *kadbi*	⅓	Silage and maize
June	1½	3	2½	1	...	...	B	⅔	Hay and *kadbi*	⅓	Napier grass, silage, maize, *bajra* and *juar*
July	1½	3	2½	1	...	...	C/B	7/12	Hay and *kadbi*	5/12	Maize, *bajra* and *juar*
August	1½	3	2½	1	...	...	C	5/12	Hay and *kadbi*	7/12	Green grass, *bajra* and *juar*
September	1½	3	2½	1	...	...	C	5/12	Hay and *kadbi*	7/12	Green grass, *bajra* and *juar*
October	2	2½	2½	1	...	...	C	7/12	Hay	5/12	Green grass silage and *juar*
November	2	2	2½	½	...	1	C	½	Hay	½	Berseem, Napier grass, silage and *juar*
December	2	2	2½	½	...	1	C	½	Hay and *kadbi*	½	Berseem, Napier grass, silage and oats
January	2½	...	2	½	...	2	C	7/12	Hay and *kadbi*	5/12	Berseem, silage, oats
February	2½	1	2	½	...	2	C	7/12	Hay and *kadbi*	5/12	Berseem, silage, Napier grass and gram
March	2½	1½	2	½*	½	2	C	7/12	Hay and *kadbi*	5/12	Berseem, oats and gram

* Fed only for one week each.

Military Farm, Bareilly (Uttar Pradesh)

The entire land (593 acres) has been brought under cultivation, and only a few acres remain for exercise. There are 288 acres which can be irrigated, 305 for dryland cultivation. Adequate water facilities make it possible to produce green fodder at all times of the year.

TABLE LVII

Fodder calendar, Bareilly

Months	Fodder	Concentrates	
			Parts
May and June	Green maize and *kadbi* 50.50	Oil cake	2
July to October	Green *juar* and *juar kadbi*	Gram	2
November	Green maize and *kadbi*	Bran	4
December to March	Green berseem, oats and *kadbi*		
April	Green berseem, maize and *juar kadbi*		

Military Farm, Panagar (West Bengal)

Livestock : Buffaloes

Grazing is available for 150 head of cattle from mid-July to mid-November on 210 acres of grazing land. No cultivation is possible as there is no irrigation water available. Green fodder crops are not grown due to damage from excessive rains. During the period when no green fodder is available, from 15th November to end of June, the animals are kept on the coarse poor-quality hay harvested from the Base-Land. Silage has been made in 1952-53; 273,000 lb. lasted from 1st January to first week of April.

Military Farm, Namkum (Bihar)

Farm now closed (1955).

Livestock : Crossbred and grade cows
Grade buffaloes.

No grazing land is available on the 300-acre farm. Hay is harvested from the forest on a royalty basis. Green fodder is inadequate from March to June and in November and December.

Military Farm, Meerut (Uttar Pradesh)

Livestock : Grade and Murrah buffaloes
Crossbred and Sahiwal cows
Bullocks, mules, horses and ponies.

Of the 2,815 acres in this farm, 2,140 acres are used for producing green fodder, *kadbi* and *bhusa*, and 675 acres for hay. The green-feed supply is difficult in the hot months of May and June. The baled hay referred to in Table LVIII is mostly imported from other farms in Eastern Command.

TABLE LVIII

Fodder calendar, Meerut

Month	Dry fodder	Parts	Green fodder	Parts	Concentrates	Parts
April	Baled hay and *bhusa*	½	Berseem and maize	½		
May	do.	⅔	do.	⅓	Gram	1
June	Baled hay	⅔	Maize and *juar*	3		
July	do.	⅔	do.	½	Bran	3
August	do.	5/12	do.	7/12		
September	do.	5/12	*Juar*	7/12		
October	*Kadbi* and hay	½	*Juar*, silage and turnips	½	Groundnut cake	2
November	do.	½	Silage, berseem and turnips	½		
December	do.	½	Silage, berseem and oats	½	Cottonseed cake	2
January	do.	½	Berseem and oats	½		
February	Baled hay	5/12	do.	7/12		
March	do.	5/12	do	7/12		

Military Farm, Lucknow (Uttar Pradesh)

The natural grazing is negligible, as most of the Farm is under cultivation (142 acres irrigated, 951 acres dry). If rains are adequate, it is possible to maintain the fodder supply throughout the year.

TABLE LIX

Fodder calendar, Lucknow

1952-53	Fodder	
Month	*Green*	*Dry*
April	Green berseem, silage	L. *kadbi*, B. hay
May	Maize, Napier	B. *kadbi*, barley *bhusa*, B. hay, gram *bhusa*
June	Maize, Napier	B. *kadbi*, berseem, *bhusa* B. hay
July	Maize, Napier and green grass	B. *kadbi*, B. hay
August	Green grass, Napier	B. *kadbi*, B. hay
September	Green grass, *bajra*, *juar* and maize	B. *kadbi*, B. hay
October	*Juar*, maize, rice, green grass and Napier	B. *kadbi*, B. hay
November	*Juar*, Napier, green grass, maize, silage	B. *kadbi*, B. hay L. *kadbi*
December	Silage, berseem, oats, green grass	L. *kadbi*, B. hay
January	Silage, oats and berseem	L. *kadbi*, B. hay
February	Silage, berseem, oats and green turnips	L. *kadbi*, L. hay and B. hay
March	Silage, oats and berseem	L. *kadbi*, L. hay and B *kadbi*

Plus concentrates (bran, gram, cake, milo and barley) in suitable proportions.

Military Farm, Kanpur (Uttar Pradesh)

Livestock : Buffaloes, bullocks, mules and ponies. The farm has 27 acres irrigated cultivation, 554 acres dryland cultivation, and 162 acres grass. Green fodder is short from April to June, pending the sinking of a tube-well.

TABLE LX

Fodder calendar, Kanpur

Period	Green fodder	Roughages
January to March	Berseem, turnips, oats, Napier grass, silage, and lucerne (for horses and mules only)	Dry *kadbi* and hay
April, May, June	Silage, early maize	Dry *kadbi* and hay
July, August, September, October, November	Monsoon grasses, green *chari*, green *bajra*, green maize	Hay
December	Berseem, turnips, silage	Hay

Bran, gram and oilcake in suitable proportions.

Military Farm, Allahabad (*Uttar Pradesh*)

Type of livestock maintained :

Sindhi cows and adult bulls	39
Sindhi young stock	28
Sindhi calves	16
Murrah and grade buffalo and bulls	129
Murrah and grade buffalo calves	23
Murrah and grade buffaloes, young stock	82
Bullocks (country)	43
Ponies and mules	10
Total average number maintained daily	370

The little grazing available from the beginning of August to the end of September in *nullahs* and other wasteland provides 25 per cent of the fodder requirement for that period.

Acreage, irrigated or dry, devoted to fodder production at Military Farm, Allahabad:

Fodder	Acres	Fodder	Acres
Turnips	2.0	*Mukchury*	1.75
Barley	6.75	*Guar* and *juar*	95.0
Berseem	5.15		
Oats	5.0	*Juar*	255.0
Maize	20.0	*Bajra*	13.5
		Total	404.0

Military Farm, Agra (Uttar Pradesh)

Livestock : Murrah and Grade buffaloes ;
Hariana cows ;
Bullocks, ponies, mules.

There are 176 acres of irrigated land, 220 acres unirrigated, and 18 acres are used for grazing from July to September each year. Green fodder is available throughout the year ; dry fodder is imported from other farms. Silage is fed in May and June and again in October when there is a shortage of green fodder.

TABLE LXI

Fodder calendar, Allahabad

Month (1952)	Green fodder	Dry fodder
January	*Juar* silage, grass, turnips, barley, berseem	Hay, white *bhusa*, *bajra kadbi*
February	*Juar* silage, grass, barley, berseem	Hay, *bajra kadbi*
March	*Juar* silage, grass, barley, berseem, oats	Hay, *bajra kadbi juar kadbi*
April	*Juar* silage, grass, berseem, maize	Hay, *juar kadbi*, gram *bhusa*
May	*Juar* silage, grass, maize	Hay, *juar kadbi*, gram *bhusa*, barley *bhusa*
June	*Juar* silage, grass, maize	Hay, *juar kadbi*, bedding
July	*Juar* silage, grass, maize	Hay. *juar kadbi*, bedding
August	Grass, *mukchury*, *juar*	Hay, *juar kadbi*, bedding
September	Grass, maize, *juar*	Hay, *juar kadbi*, bedding
October	Grass, maize, *juar*, *bajra*	Hay *juar kadbi*
November	Berseem, *juar*, *guar*	Hay
December	Berseem, oats, *juar-guar*, *bajra*, silage	Hay, *juar kadbi*, bedding

Table LXII

Acreage under fodder crops, Agra

Crop	Acreage
Kharif :	
Maize	15
Juar and *bajra*	367
Total	382
Rabi :	
Turnips	10
Oats	94
Berseem	33
Gram	32
Barley	16
Lucerne	2
Total	187

Table LXIII

Fodder calendar, Agra

Month	Crop
April	Berseem and green oats
May	Barley, maize and *bajra*
June	*Juar* and *bajra*
July	*Juar* and *bajra*
August	*Juar* and *bajra*
September	*Juar* and *bajra*
October	*Juar* and *bajra*
November	*Juar* and *bajra*
December	Berseem, oats and turnips
January	Berseem, oats and turnips
February	Berseem and oats
March	Berseem and oats

Livestock : Cows, buffaloes, bullocks, horses, mules and ponies.

Grazing is available on some farms from July to October, when it provides about 25 per cent of the animals' requirements.

TABLE LXIV

Acreage available for fodder production in the various Farms

Farm	Acreage	Land use
Mhow	200	Dryland fodder
	600	Monsoon grass
Ambala	203	Irrigated
	1,116	Dryland
	110	Grazing
Bir Dhantouri	40	Irrigated
	375	Monsoon crops
Ferozepore	569	Irrigated
Jullundur	249	Irrigated
	238	Dryland
	120	Grassland
Bir Sarangwal	187	Irrigated
	575	Dryland

TABLE LXV

Fodder calendar, Military Farms, Punjab and PEPSU

Name of Farm	January			February			March		
	Green	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*
Mhow	Silage, oats, berseem, barley	Dry grass	Gram, bran, oilcake	Silage, berseem, barley	Dry grass Dry *kadbi*	Gram, bran, oilcake	Silage, berseem	Dry grass Dry *kadbi*	Gram, bran, oilcake
Ambala	Oats, berseem, Veg. leaves, silage	Hay, *bhusa*, *kadbi*	Bran, gram, oilcake, milo/maize	Oats, berseem	Hay, *bhusa*, *kadbi*	Bran, gram, oilcake	Oats, barley, berseem, *chari*	Dry *bhusa*	Bran, gram, milo, maize
Bir Dhantouri	Berseem, oats	Paddy, straw or *juar kadbi*	Bran, gram, oilcake, milo or maize	Berseem, oats	Dry hay, paddy straw or *juar kadbi*	Bran, gram, oilcake, milo or maize	Berseem, oats	Dry hay, paddy straw or *juar kadbi*	Bran, gram, oilcake, milo or maize
Kasauli	...	Dry hay	Bran, gram, oilcake	...	Hay	Bran, gram, oilcake	...	Hay	Gram, bran, oilcake
Ferozepore	Berseem, lucerne, oats	Hay, *bhusa*	Gram, bran, oilcake	Berseem, oats, lucerne	Hay, *bhusa*	Gram, bran, oilcake	Berseem, oats, lucerne	Hay, *bhusa*	Gram, bran, oilcake
Jullundur	Berseem, oats, silage	*Bhusa*, hay	Gram, bran, oilcake	Berseem, silage, oats	*Bhusa*, hay	Gram, bran, oilcake	Oats	Hay	Gram, bran, oilcake

TABLE LXV (contd.)

Name of Farm	April			May			June		
	Green	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*
Mhow	Silage, maize	Dry grass, *kadbi*	Gram, bran, oilcake	Silage, maize	Dry grass, hay, *kadbi*	Gram, bran, oilcake	...	Hay, *kadbi*	Gram, bran, oilcake
Ambala	Oats, barley lucerne, berseem, veg. leaves	Hay, oat hay	Gram, bran, oil cake, milo	Lucerne, berseem, green grass, green maize	Hay, oat hay/ *bhusa*	Gram, bran, oilcake, milo	Lucerne, green grass, maize, *chari*	Oats, *bhusa*, missa, barley, hay	Gram, bran, oilcake, milo
Bir Dhantouri	*Juar*, silage, E/maize	Dry hay, paddy straw, *kadbi*	Gram, bran, oilcake, milo/maize	*Juar*, silage	Hay, paddy straw, *juar*, *kadbi*	Gram, bran, oilcake, milo or maize	*Juar*, silage, E/maize	Dry hay, paddy straw, *kadbi*	Gram, bran, oilcake, maize
Kasauli	...	Hay		...	Hay	Gram, bran, milo, oilcake	...	Hay	Gram, bran, oilcake
Ferozepore	Berseem, oats, lucerne	Hay and *bhusa*	Gram, bran, oilcake	E/maize, oat silage	Hay, *bhusa*	Gram, bran, oilcake	E/maize, oat silage	Hay, *bhusa*	Gram, bran oilcake
Jullundur	Berseem, oats	*Bhusa*, hay	Gram, bran, oilcake	berseem, silage	*Bhusa*, hay	Gram, bran, oilcake	E/maize, silage	*Bhusa*, hay	Gram, bran, oilcake

TABLE LXV—(contd.)

Name of Farm	July			August			September		
	Green	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*
Mhow	Green *chari*	Hay, *kadbi*	Gram, bran, oilcake	Green *chari*, maize	Dry grass, dry *kadbi*	Gram, bran, oilcake	*Chari*, maize	Dry grass	Gram, bran, oilcake, barley
Ambala	Oat, barley, lucerne, green grass, maize *chari*	Barley, berseem, *bhusa*, hay	Gram, bran, oilcake, millet, maize	Lucerne, grass, maize, *chari*	Hay, *bhusa*	Bran, gram, oilcake, milo/maize barley	Grass, maize, *chari*	Hay, *bhusa*	Bran, gram, oilcake, milo, maize. barley
Bir Dhantouri	Green *juar*	Dry hay, paddy straw, *kadbi*	Gram, bran, oilcake, milo, maize	Green *juar*	Hay, paddy straw, *kadbi*	Gram, bran, oilcake, milo or maize	Green *juar*	Dry hay, paddy straw or *juar kadbi*	Gram, bran, oilcake, milo or maize
Kasauli	...	Dry grass	Gram, bran, oilcake, milo or maize	...	Dry hay	Bran, gram, milo, oilcake	Green hay	Dry hay	Bran, gram, oilcake
Ferozepore	Maize *chari*	Dry hay, *bhusa*	Gram, bran, oilcake, milo or maize	Maize, *chari*	*Bhusa*, hay	Gram, bran, oilcake	Maize, *chari*	Hay, *bhusa*	Gram, bran, oilcake
Jullundur	E/maize, silage	*bhusa*, hay	Gram, bran, oilcake, milo or maize	*Chari* maize	*Bhusa*, hay	Gram, bran, oilcake	*Chari*	*Bhusa*, hay	Gram, bran, oilcake

TABLE LXV—(contd.)

Name of Farm	October			November			December		
	Green	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*	*Green*	*Roughage*	*Concentrate*
Mhow	*Chari*, maize	Dry grass Dry *kadbi*	Gram, bran, oilcake, barley	Silage	Dry grass, dry hay	Gram, bran, oilcake, barley	Silage G/oats, G/berseem	Dry grass	Gram, bran, oilcake
Ambala	Maize, *chari*, milo	Hay, *bhusa*	Bran, gram, oilcake, milo, maize	Maize, *chari*	Hay, *bhusa*, *kadbi*	Bran, gram, oilcake, milo, maize	Berseem, vegetable leaves, *chari*, silage	Hay, *bhusa*, *kadbi*	Bran, gram, oilcake, milo or maize
Bir Dhantouri	Green *juar*	Hay, paddy straw, *kadbi*	Gram, bran, oilcake, milo or maize	Green *juar*	Dry hay, paddy straw, *juar*, *kadbi*	Gram, bran, oilcake, milo or maize	*Juar* silage, berseem, oats	Dry hay, paddy straw, *juar kadbi*	Gram, Bran, oilcake, milo or maize
Kasauli	Green grass	Dry hay	Bran, Gram, oilcake	...	Dry hay	Gram, bran, oilcake	...	Hay	Bran, gram, oilcake
Ferozepore	Maize, *chari*	Hay, *bhusa*	Gram, bran, oilcake	Maize, *chari*, silage and berseem	Hay, *bhusa*	Gram, bran, oilcake	Berseem, oats	*Bhusa*, hay	Gram, bran, oilcake
Jullundur	*Chari*	*Bhusa*, hay	Gram, bran, cake	*Chari*, silage	*Bhusa*, hay	Gram, bran, cake	Berseem, oats	*Bhusa*, hay	Gram, bran, oilcake

Conclusion

Several preliminary conclusions may be drawn from these practical accounts of how different types of livestock are actually maintained and fed on larger properties in different parts of India.

(1) Grazing is of little importance and can be practised for only four to five months per year; grazing is of no value for high-producing dairy stock.

(2) Grass and legume species are available to provide cultivated green fodders, particularly if irrigation water is available.

(3) The summer period, March to June, is always difficult; it can be overcome by conservation of surpluses grown at other times of the year or by the cultivation of irrigated summer fodders.

(4) Concentrates and grains are important, partly to provide maintenance because of the low quality of most of the roughages available, and partly to act as a production ration for dairy cows and working animals.

(5) By proper planning of the proportions between natural grazing, haylands and acreages for the cultivation of dry and irrigated fodders, and with proper attention to the conservation of silage, hay and crop residues, it appears to be quite possible to maintain high-quality livestock on a uniform plane of nutrition throughout the year.

CHAPTER IX

VILLAGE GRAZING LANDS

WE have shown how cattle of the various Indian breeds, Sindhi, Sahiwal, Hariana, Tharparkar, Gir and others, may be maintained on larger properties, both State and private, by providing nutriment in a year-round pasture and fodder calendar. The fodder supply has to be based on material from all possible sources, from crop residues to high-protein concentrates. The better the cattle, the less use can they profitably make of the grazing land in India, until with high-producing dairy stock the operation of grazing becomes practically synonymous with exercise. Because of the average low nutritive value of grazing and roughages in India, some of the concentrate ration must be used in the first place to assist any high-quality leguminous hay which may be available to meet the maintenance ration.

Farms of this type do not necessarily require to keep cattle for cultivation or domestic milk supplies, although they may do ; because the livestock are generally superior animals of their various breeds, the surplus animals which inevitably arise can be disposed of by sale to the villages. In many of the State properties, the economics of fodder production and feeding are not of primary importance, and feeds and concentrates may be purchased in the open market to maintain a relatively costly but uniform plane of nutrition throughout the year, and particularly over the critical period from March/April to June/July.

The villager, on the other hand, feels secure if he has his pair of working males to cultivate the land plus the females to produce new males for himself or for sale, plus the buffalo to give the high-fat milk which can be turned into ghee for cooking. The bullocks and the cows are part of his household and the economics of their maintenance do not necessarily arise. Any feeds which the villager might have available go to his working animals and his buffalo. The cows and the young stock receive a minimum of hand feeding because of the great shortage of fodder ; so one obtains long intervals between calving and stunted growth calves.

We have shown on a State basis in Table IV the number of animals per cultivated acre and per fodder acre, with averages for the country of 0.6 and

16.8 respectively. Table XCIV shows the great preponderance of very small farming units in which anything approaching mixed farming, an integration of food and cash crops with fodder crops, is most difficult if not impossible to achieve. Further we shall, in Chapter XVI, give the local background against which the whole problem must ultimately be considered, the agrarian structure, the human and livestock populations and the acreages available in a number of representative villages.

Together, these figures reveal the great and basic problem of Indian agriculture and land use, that of adjusting practices in such a way as to feed the village livestock population. Veterinary services are, quite rightly in one respect, rapidly closing one of the safety valves, the loss of animals through disease. Livestock improvement is being promoted through artificial insemination centres, breeding units and mass castration operations. Livestock are, therefore, being bred which have higher demands for nutriment, both in quantity and quality, if they are to express their full potentialities. Crop improvement through the use of fertilizers, better cropping practices and the use of seeds of improved crop varieties will increase the amounts of certain crop residues available for feeding; the cultivator may be able to obtain higher yields of food grains and cash crops, but will this induce him to reduce his acreage under these crops and to grow fodder for his livestock, or will he prefer to improve his food and financial situation without reduction of food and cash crop acreage?

The third party in any scheme of livestock improvement, the fodder agronomist and crop ecologist, is faced with the superhuman task of suggesting how the fodder and grazing practices of a village might be improved. To increase the proportion of fodder crops in relation to other crops is a task for education; the usual basis of argument would be that a fodder crop can give as good an economic return per acre as the cultivated crops, if one also considers the returns obtained from the food and cash crops through the increase in soil fertility in properly designed rotations. But the average Indian livestock cannot possibly give an adequate return in the form of animal products, and the soil fertility cannot be greatly increased since most of the animal manure must necessarily be used as fuel. A poor farmer living at a subsistence level on a tiny acreage is not going to grow an increased fodder acreage under these circumstances.

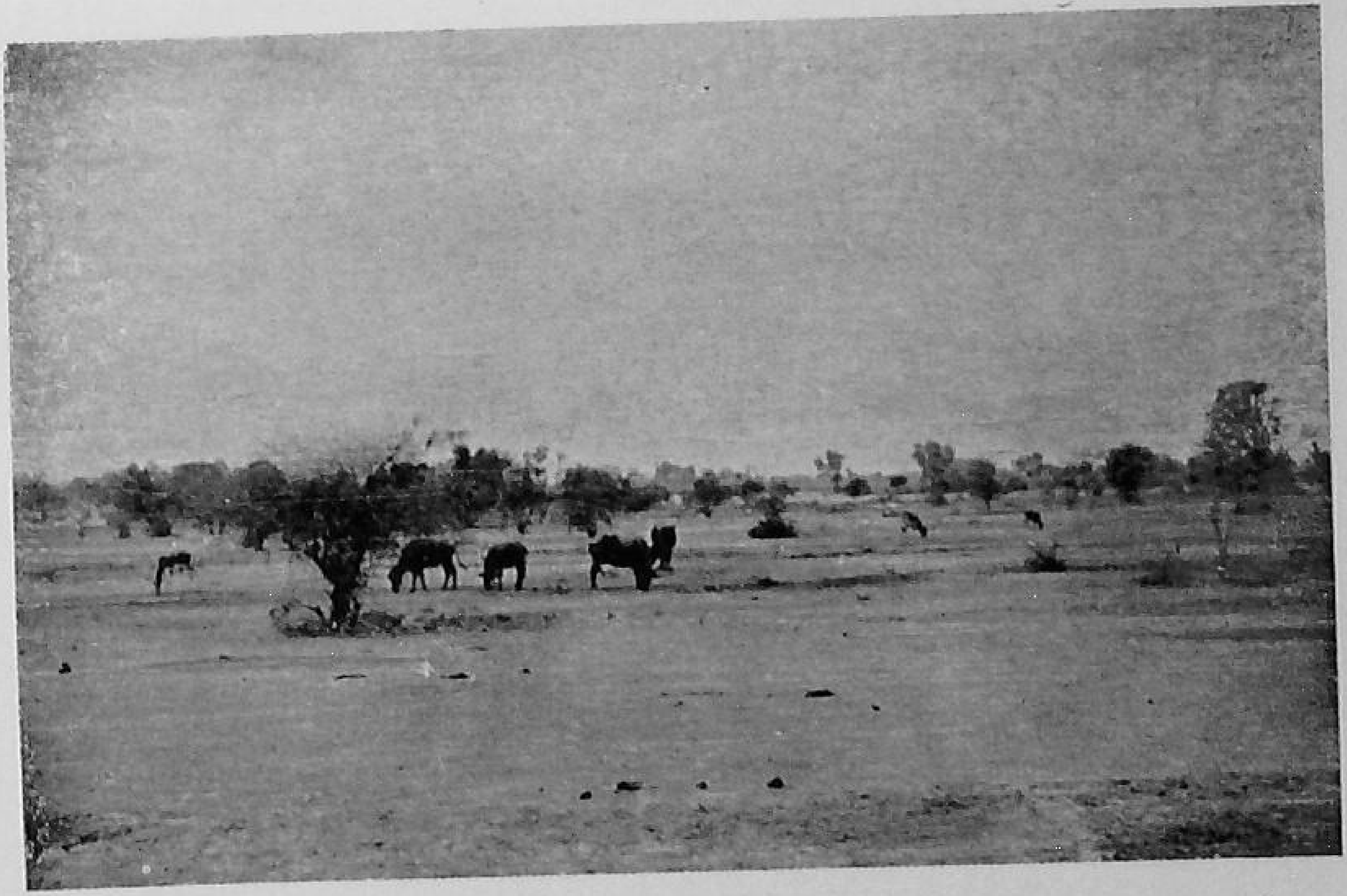
Regeneration of Village Pastures

This brings us to the village pastures or grazing grounds. The average

PLATE XXI

Miserable half-starved cattle on forest grazing grounds near a village, the result of uncontrolled grazing at nominal rates in reserved forest. Mandla Division, Madhya Pradesh

Photo : M. V. Laurie



Cattle grazing on the scanty herbage on alkaline land in Uttar Pradesh, representative of some three million acres in that State

Photo : R. O. Whyte

state of these is poor in the extreme. Near the village they are completely denuded of grass cover, which is frequently replaced by the leguminous and other plant indicators of severe overgrazing. Such land has a very high run-off during the rains, and acts as a septic focus from which water flows to cut its way through valuable cultivated land lower down in the same catchment area. Conditions are such that there is actually only one major method of reclamation, and it tends to be agreed that this cannot be applied in general in the absence of directive or strongly persuasive powers.

The reseeding of pastures following ploughing, the normal method of producing improved pastures in certain Western countries, cannot be adopted on any scale in India for several reasons : (a) if land is ploughable, it must surely be used for the production of food and cash crops, with, it may be hoped, the cultivation of rapidly maturing leguminous fodder crops in the rotation, (b) ploughing up and reseeding, involving considerable expenditure on cultivation, fertilizers and seeds, is an economic operation only in the presence of high-producing livestock, (c) pasture reseeding has not yet been shown to be a practicable proposition in India, and in any case seeds of indigenous or adapted exotic grasses are not available in any quantity (see, however, the section on seeding and manuring below).

The situation does not appear to have changed much since Burns wrote (1915). "In India, the question of fodder for cattle is perennial......................It seems absolutely necessary, if a new grass or mixture is to be established, that the land must be cleaned fairly well of existing vegetation, the seeds carefully sown and rolled in, weeding occasionally done, and cattle rigidly excluded until the new growth has taken hold. If the establishment of improved fodder plants requires all this attention, it may well be asked whether it is worth the trouble. Experiment alone can determine. When once a strong perennial grass gets hold of a suitable locality, it is not easy to shift and the labour of establishing it may be repaid".

Perhaps the outstanding example where a good fodder grass has been artificially introduced into cultivated pasture is on the lands of the breeder of the famous Kangayam herd, the Pattagar of Palayakottai, in Coimbatore District of Madras State. Here *Cenchrus ciliaris* (known locally as *kolukattai* grass) has been in cultivation from time immemorial ; it is present in almost every village in the locality, Kangayam *firka*. Grey loams rich in lime are considered to be the best. The land is ploughed in the hot weather rains and the grass seed is sown either

alone or mixed with *juar*, gingelly (*Sesamum indicum*) or other species. The land is usually manured at sowing time, and the manure is provided subsequently by the cattle grazing in the area. The pasture lasts for many years and is then ploughed or reseeded or broken up for crop production. No grazing of sheep, goats and ponies is permitted in the first year since they bite so close to the ground (Krishnaswamy V.S. and Venkataramana Reddy, 1953).

Because of the difficulties of reseeding under Indian conditions, it is necessary to utilize the remarkable capacity of Indian grasslands for rapid regeneration after protection from serious misuse, in other words, ecological management. The first pre-requisite is the removal of the main biotic factor, the grazing animal. The regeneration which then practically invariably occurs within a period of over three years may be accelerated by hand removal of shrub growth, hand hoeing of the surface before the rains, and contour or other furrowing to facilitate retention of moisture. Perhaps experiments may later prove that a light surface seeding of adapted indigenous grass seeds will accelerate the regeneration and the ecological succession. There is no indication yet that legumes resistant to grazing can be established and maintained in any significant proportion on such pastures. The application of fertilizers is an extremely doubtful proposition economically.

Proposal A : The main problem is, therefore, the temporary removal of the grazing animal and subsequently a very severe reduction in grazing intensity. An average figure is difficult to obtain, but it may be said roughly that the stocking rate should change from its present figure of three beasts per acre for the whole year to one beast per two acres for four months only. This is a very approximate measure of the present degree of over-stocking. It is necessary to change from a year-round grazing system to a system based primarily on hand feeding in dry lots or yards with possibly a little completely controlled grazing for a very limited period of the year and on a restricted acreage. Anyone with any experience of the suspicions and individual liberties of the villager will appreciate the impossibility of achieving any such radical change without control or intelligent co-operation. And yet it appears to be the only feasible method which might be adopted to increase the fodder provided by the village pastures and at the same time help them to contribute towards the conservation of soil and water.

We may elaborate the method for purpose of clarification. Apart from the revolutionary change from the year-round practice of what amounts to

free-range grazing to hand feeding for some months in each year in dry lots or yards, most of the suggestions made refer to minor adjustments which might profitably be made in normal village practices and customs.

Although, as already stated, it is impossible to give any exact estimate, we may, for the sake of argument, accept the figure of three beasts per acre as the normal year-round rate of stocking on village pastures, particularly in close proximity to the village itself. This type or lack of management reduces the pasture to the equivalent of an exercise ground for most of the year. If it is a denuded exercise ground at three beasts to the acre, it will still be no worse at 20 beasts to the acre. The concentration of the stock in, say, one-seventh of the total grazing area would transform that part into a dry lot. Simple feeding cribs could be provided for economic utilization of fodder. Adequate shade would have to be provided. The remaining six-sevenths of the village pasture would be completely protected from grazing, and given the simple treatments referred to above, namely, clearance of brush and useless bunch grasses, improvement of moisture retention capacity of soil by hoeing or contour furrowing, with perhaps some surface sowing.

The rate of regeneration of a superior grass cover will depend on the degree of misuse to which the grazing ground has been subject, the grass species which remain, to provide self-sown seed, and probably the rainfall. Regeneration is likely to be more rapid under a high than under a low rainfall.

If we allow two to three or more years for this regeneration to the desired ecological level, the problem arises of feeding the livestock during these years. If adequate supplies of crop residues are not available from the cultivated land, it may be necessary to defer the change to dry-lot feeding for three years. During this period, an area of the village pasture may be protected from all grazing, and cut once only per annum for hay. After protection for about three years, this area will be in a position to provide a reasonable amount of cut fodder for the animals which might then be concentrated in a dry lot.

Within a further period of three years following this concentration and adoption of hand feeding, the whole pasture will now be considerably improved, and will be providing more fodder in a cutting regime than by the former haphazard grazing ; one State says that double the yield may be obtained after closure for three to five years, and the grass species are by that time superior to those to be found in the overgrazed pasture.

Proposal B. The recommendations would be successful only if there is complete co-operation among the people of a village who own cattle. Otherwise it is doubtful if the key to Proposal 'A', namely, common feeding in dry lots or yards, would be practicable and acceptable. Villagers fully realize that many of their livestock are not worth the effort of hand feeding.

Kumar (1954) has produced an alternative scheme for the reconditioning over a ten-year period of village grasslands which have been denuded of vegetation by uncontrolled and excessive grazing. This scheme still demands hand feeding for part of the year.

One-tenth of the grazing area should be completely closed to all grazing for one year. The grass may be cut after maturity when the seeds have fallen to the ground. This grass hay or straw may be sold to the villagers for stall-feeding or probably stored for use during hot weather. In the following year, another tenth of the grazing area should be added to the first and treated in the same way. After the third year when three-tenths of the area has been reclaimed, the whole may be opened to controlled grazing. The main objective now is to prevent year-round grazing. The animals should be allowed to enter the pasture after the commencement of the rains, by which time the grasses will have made sufficient growth to withstand browsing and trampling. Grazing should end when the hot weather sets in.

This procedure may be repeated until the entire grazing area of the village has been reconditioned. The number of cattle to be grazed in the reclaimed area should equal the carrying capacity of the area or at most should not exceed one-and-a-half times that capacity. While grassland reclamation is in progress, every attempt should be made to reduce drastically the number of unserviceable cattle. Restoration of village grazing land and its preservation in a reasonable condition will be practicable only when the measures suggested have been adopted, namely, closure to permit revegetation, controlled grazing during a limited season, closure during hot weather, and reduction in number of non-utility cattle.

Village Animal Husbandry

In order to assist village stock owners in improved feeding of their better cattle, these should in due course be transferred from the dry lot to a simple type of stall, with a properly designed and drained concrete floor, feeding cribs and a *kutcha* roof. It is fully appreciated that this pooling of the superior working,

milking and breeding animals in one or more communal units demands a degree of mutual trust among villagers which may not always exist at the moment.

Many villagers have a washing place for themselves and their clothes from which the surplus water runs to waste in the ground nearby. This surplus may well be run through the floor of the open cowshed, from which it would flow with some of the valuable liquid from the dung and urine. If it were then directed to a nearby patch of cultivated land on which is growing a grass capable of responding to such rich manuring, e.g. Para grass, a year-round supply of nutritive cut green fodder would be available for feeding to the better bovines in the stalls.

Cattle manure is a very valuable commodity in village life. Although most of it is dropped by the livestock in their present pens at night, much is still wasted during grazing in the surrounding lands or forests. A change to dry lot, yard or stall-feeding would mean that all the manure could be conserved. Perhaps one may hope that, although part of it would still be dried for use as fuel, part may become available for return to the land.

It is only by practical measures and simple adjustments such as these that any initial improvement can be effected in village methods of keeping livestock, and so incidentally in the capacity of adjacent grasslands and uncultivable areas to supply feed and conserve soil and water. Animal husbandry does not feature to any extent in the plans of the Community Centres ; an approach of this kind might be acceptable to practically-minded villagers, and considerable improvements might thereby be effected.

Steps in this direction have already been taken. The Economic Botanist in Bombay State has been given facilities to fence off about 50 acres in village pastures of 200 acres or more in Community Centres in the north, centre and south of Bombay State. Simple improvement measures can then be carried out and within a few years the villagers will have a clear demonstration of the capacity of their grassland to regenerate.

Similar action is being taken in several Community Centres in Uttar Pradesh. The surplus livestock are being removed to concentration camps in the Terai, and pasture improvement on the same lines will then be carried out in the villages. It is hoped that all States will follow this lead, so as to demonstrate both to the ocal officers of the Agriculture Department and to the villagers what the various types of grassland in India a recapable of producing under intelligent and controlled management.

Seeding and Manuring

Little evidence is available on methods of seeding pasture grasses and legumes in India. It has already been indicated that this would involve ploughing and cultivation, and that there would in most cases be a tendency to grow food and cash crops on land which can be so cultivated. There are, however, some results available from Bombay State and Madhya Pradesh and also examples of attempts at grass reseeding and establishment in forest grasslands.

Within the Agricultural College Estate at Dharwar in South Bombay State, a grass-covered strip of abandoned crop land was used for an experiment on pasture reseeding combined with the application of farmyard manure. The treatments adopted and results obtained are given in Table LXVI.

Table LXVI

Results of manuring and reseeding experiment at Dharwar

Treatment	Dry fodder yield in lb. per acre		
	1950-51	*1951-52*	*1952-53*
Control	2,071	2,919	4,299
Seeded	2.239	4,311	3.867
Manured	2,245	4,048	4,884
Seeded and manured	1,678	5,457	3,406

Over a three year period, it was observed that yields increased appreciably after all three treatments in the second year, but that there was a fall in yield with two treatments in the third year. Apparently, only with manuring can the increased yield be maintained beyond the second year.

In another experiment, three grasses and three legumes were tested singly and in various combinations and proportions in four replications at the Manjri Kuran near Poona. Each mixture consisted of two grasses and a legume; the total quantity of seed used for each treatment was 28 grm. on replicated plots each 10x20 ft. in area. The forage was cut once a year and the yield recorded in terms of green weight.

TABLE LXVII

Yields of grasses and legumes sown alone and in various combinations

(Average of 3 years)

	Proportion	Average yield in lb.
Grass		
1. Marvel (*Dichanthium annulatum*)		84
2. Blue panic (*Panicum antidotale*)		91
3. Rhodes (*Chloris gayana*)		64
Legume :		
4. Barbada (*Indigofera glandulosa*)		49
5. Shevra (*Alysicarpus rugosus*)		37.5
6. *Centrosema pubescens*		57
Mixture :		
1. Marvel, Barbada, Blue panic	1 : 2 : 1	66.5
2. *Centrosema*, Marvel, Rhodes	1 : 2 : 5	71.25
3. Rhodes, Shevra, Blue panic	1 : 3 : 4	94.5

These grass/legume mixtures on light soils were not superior in yield to some of the grasses sown alone. All the legumes were inferior to the grasses or mixtures. Only the mixture Rhodes/Shevra/Blue panic in a 1 : 3 : 4 proportion was superior to the best grass.

In an experiment at Dharwar with a mixture of *Dichanthium annulatum* and *Alysicarpus rugosus*, the legume responded to an application of sulphur as fertilizer, and the grass benefited by association with the legume. In another trial at Manjri, near Poona, superior types of grasses and legumes which had been sown on light soils were unable to compete with the original coarse grasses during adverse weather conditions in successive seasons. On the other hand, certain introduced grasses show a tendency to spread naturally from plots and other areas where they have been established, for example, Natal grass (*Tricholaena rosea*),

thin Napier (*Pennisetum polystachyon*) and *P. pedicellatum*, and to a slight extent *Chloris gayana* and *Panicum antidotale*.

The Teaching Botanist, Nagpur, is also conducting comparative and seeds-mixture trials with grasses and legumes. The best production of green and dry fodder from annual grasses was obtained from *Pennisetum pedicellatum* and *Thelepogon elegans*. A new strain of sweet Sudan grass has given five cuttings of green fodder from August to February under unmanured rainfed conditions, with a wet yield of 30 tons per acre. Among the perennial grasses, the best were *Chloris bournei* (28 wet tons in four cuts) and *Pennisetum polystachyon* (26 wet tons in two cuts).

The seeding rate for the standard grass/legume mixture has been reduced from 100 to 60 lb. per acre. Best yields were obtained in a cutting experiment when cuts were made in November ; cutting in September delayed the January cut, and had an adverse effect on regeneration and yields of later cuts. Some of the sown grasses could compete well with inferior coarse grasses like *Heteropogon contortus* and *Anthistiria ciliata*.

Rotational grazing experiments

The study of grassland management which began in Bombay State in 1912 led to the publication of several papers by Burns and others. Attention was first given to the ecological aspects, but this later changed to the study of grassland management with special reference to grazing. Two grazing experiments conducted over a decade show the benefit of the rotational or intermittent intensive method of grazing on grazing lands which have not been too seriously damaged (Kumar, 1954). (See also experiments on rotational and controlled grazing on regenerated alkaline land in Chapter XIII.)

Bhamburda, Poona

An area of 40 acres of typical *kuran* (natural grazing area) receiving a rainfall from 15 to 20 inches annually was utilized for experimentation and improvement. As a first step, the area was bounded with small contour *bunds* constructed from small stones scattered over its surface. The experimental area was then divided into four equa blocks or compartments. Twenty cattle were used in grazing the blocks in rotation. Each year, one of the blocks was reserved for natural reseeding while the remaining three were rotationally grazed.

Block III, containing the coarsest, tussocky grass, was opened first for grazing while Block IV, the poorest was grazed last. This allowed time for grasses in the Blocks in which growth was slow and poor to root themselves firmly to withstand trampling and browsing early in the season. Block I was closed to grazing until the seeds had dropped, and hay was cut and stored, so that only the second growth was available for grazing. After four years, at the close of one complete rotation, the number of plants found on a unit of ground had increased almost three-fold, and the tussocks of grass had grown almost to three times their original size. The original poor grazing land had rapidly acquired better vegetation, a higher percentage of legumes and increased growth of trees and bush. The experimental area had changed from a barren and scantily covered one into a moderately well-covered and useful area for grazing, which could provide more cattle with palatable and more nutritious feed.

Mangdara Kuran *near Poona*

For this experiment a larger grazing area of 500 acres of *kuran* land, partly on the slope of a hill and partly on bottom land, was utilized. All the gullies were blocked with plugs or *bunds* and the area divided into four equal blocks. One block was closed to grazing each year while the remaining three were rotationally grazed. Shifts of cattle from block to block depended entirely upon the condition of vegetation in a block and did not work to any pre-determined order of rotation. The area was not fenced, the blocks being demarcated by natural objects such as a tree or large boulder. Three herdsmen were engaged to keep the 250 cattle confined to the block being grazed at any one time.

After seven years, the vegetation had improved, the cattle had gained in condition and the village herdsmen could be trained to carry out the rotational method of grazing ; the operation was simple and inexpensive. For implementing this method, all that was needed was willingness on the part of villagers to adopt the measure and follow it strictly.

Wherever controlled grazing of the rotational type has been practised, the following advantages have been observed :

a) the vegetation is afforded a chance to make better growth ;

b) young and nutritious grass becomes continuously available as feed during the grazing period ;

c) the grazing season becomes prolonged ;

d) the cattle maintain condition ;

e) inferior and coarse grasses gradually give place to superior types ;

f) soil erosion is reduced ; and

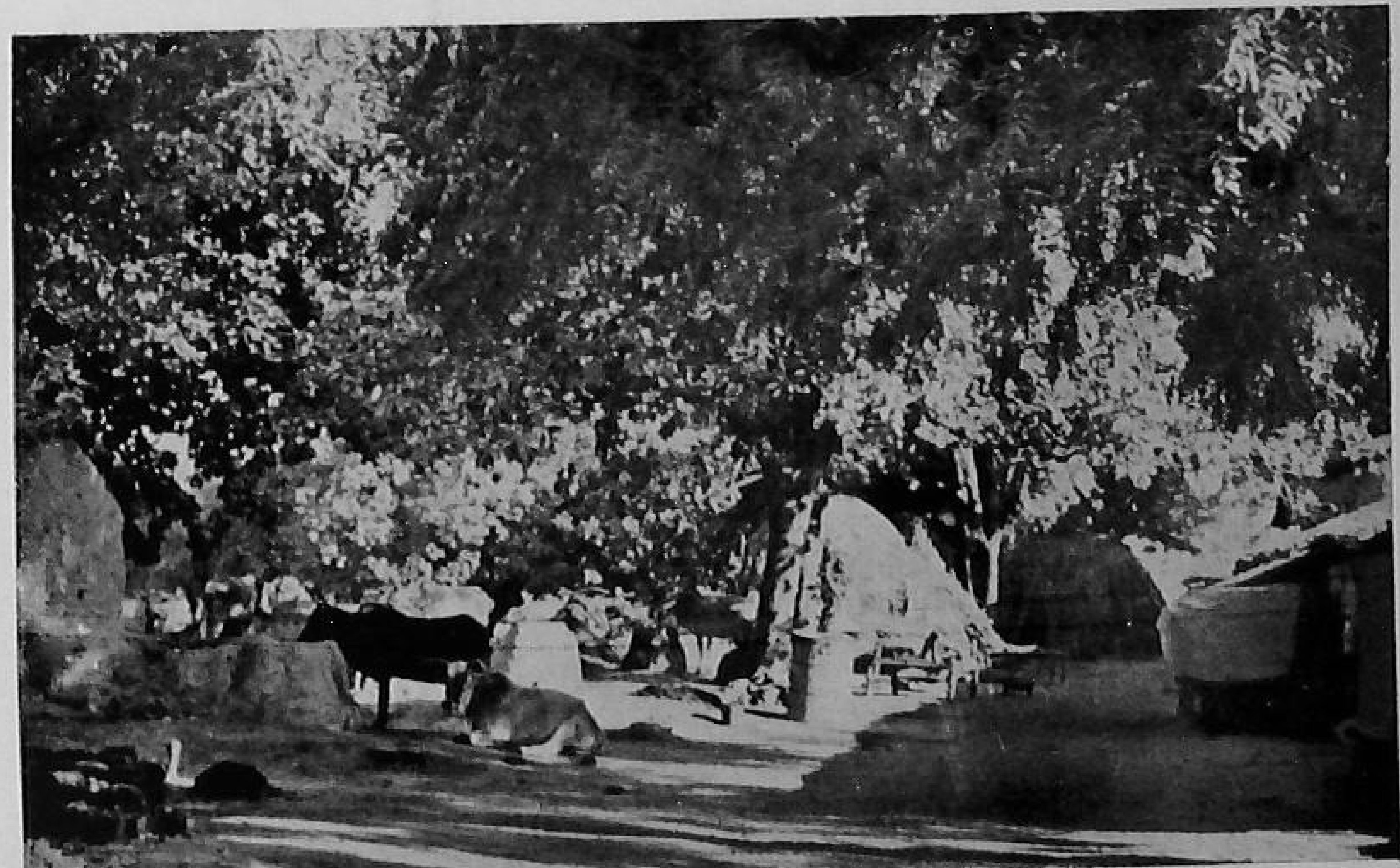
g) seedlings and saplings of forest trees are not damaged or browsed by cattle since sufficient feed is available for them.

With the experience gained from rotational grazing experiments, continuous efforts have been made to extend the practices in grazing areas throughout the State by means of popular articles in magazines, by exhibiting coloured posters and models at agricultural exhibitions, by giving talks, etc. The adoption of improved practices by the graziers in this State has, however, been rather slow and will require consistent effort in extension of this method.

Plate XXII

Migratory sheep and goats used as pack animals, in a temporary corral in *Pinus longifolia* forest near Ranikhet, Utter Pradesh

Photo : R. O. Whyte



A village scene, Uttar Pradesh

Photo : R. O. Whyte

CHAPTER X

NOMADIC AND MIGRATORY GRAZING

THERE are, more particularly in Northern and Western India, many examples of migratory forms of animal husbandry or transhumance which introduce serious problems of pasturage, animal feeding and erosion. Under this head we must consider the annual seasonal movements of stock from the high summer pastures to the low elevation winter pastures in Kashmir, Himachal Pradesh an other parts of the Western Himalaya, or from the high country around Ranikhet Almora and beyond to the savannah grasslands of the Terai and Bhabar.

Kashmir

Control of grazing in and outside the demarcated forest in Kashmir was, until 1920, vested in the Revenue Department. After their expulsion from the Punjab and the Northwest Frontier Province, the nomad *bakarwals* are reported to have entered Kashmir State, and with the *gaddis* caused the deterioration of the grasslands, those of the scrub forests of the sub-montane tracts having suffered most. The control of fluctuating grazing was made the responsibility of the Forest Department in 1939, but this appears to have had little effect and the problem is as acute as ever.

Kulu and Kangra Valleys, Punjab

Specific routes are prescribed for the movement of the sheep of the professional sheep men to the summer pastures in the upper Himalaya. It is further desired that the flocks must progress at least five miles each day, and that they must not usually stop at a halting place for more than a night, except when delayed by rain or when salt has to be given. The flocks are precluded from grazing in demarcated forests, and may graze only in second class demarcated and undemarcated forests through which they pass between certain specified dates (June 27 to October 5 in Kangra). On their way to the rich pastures of the high Himalaya, flock after flock traverses the same route, where the pastures have already been grazed bare by the first arrivals and by the local domestic village animals. Although guards are there to attempt to enforce the regulations along the route, the pastures are grazed to the ground by the end of the spring migration and the bare soil lies exposed to the subsequent rains. Attempts to limit the

numbers by increasing the grazing tax (see Table LXXVII) have failed owing to defective enforcement (Glover, 1946), or too low a rate of taxation and the absence of alternative means of livelihood for the shepherds (Mohan, 1954).

In the former Himalayan States, people cannot live by agriculture alone, and keep flocks of sheep and goats. Many are pastoralists. Migrants come from other parts, encouraged by State officials to bring their buffaloes for the sake of the milk, butter and *ghee* which they provide. In the Chamba State, from which most *gaddis* come, the grazing runs are auctioned and the contractor necessarily tries to introduce as many animals as he can. The whole country is overrun by hungry sheep, goats and buffaloes (Glover, *loc. cit.*).

Increase in numbers of livestock has led to overgrazing along the well-worn routes followed and the regressive types of grassland so produced are not able to meet the nutrient demands of the livestock. Particularly is this the case on the return journey in the spring and early summer from the plains and foothills to the high altitudes, through sites which have been heavily grazed on the downward journey.

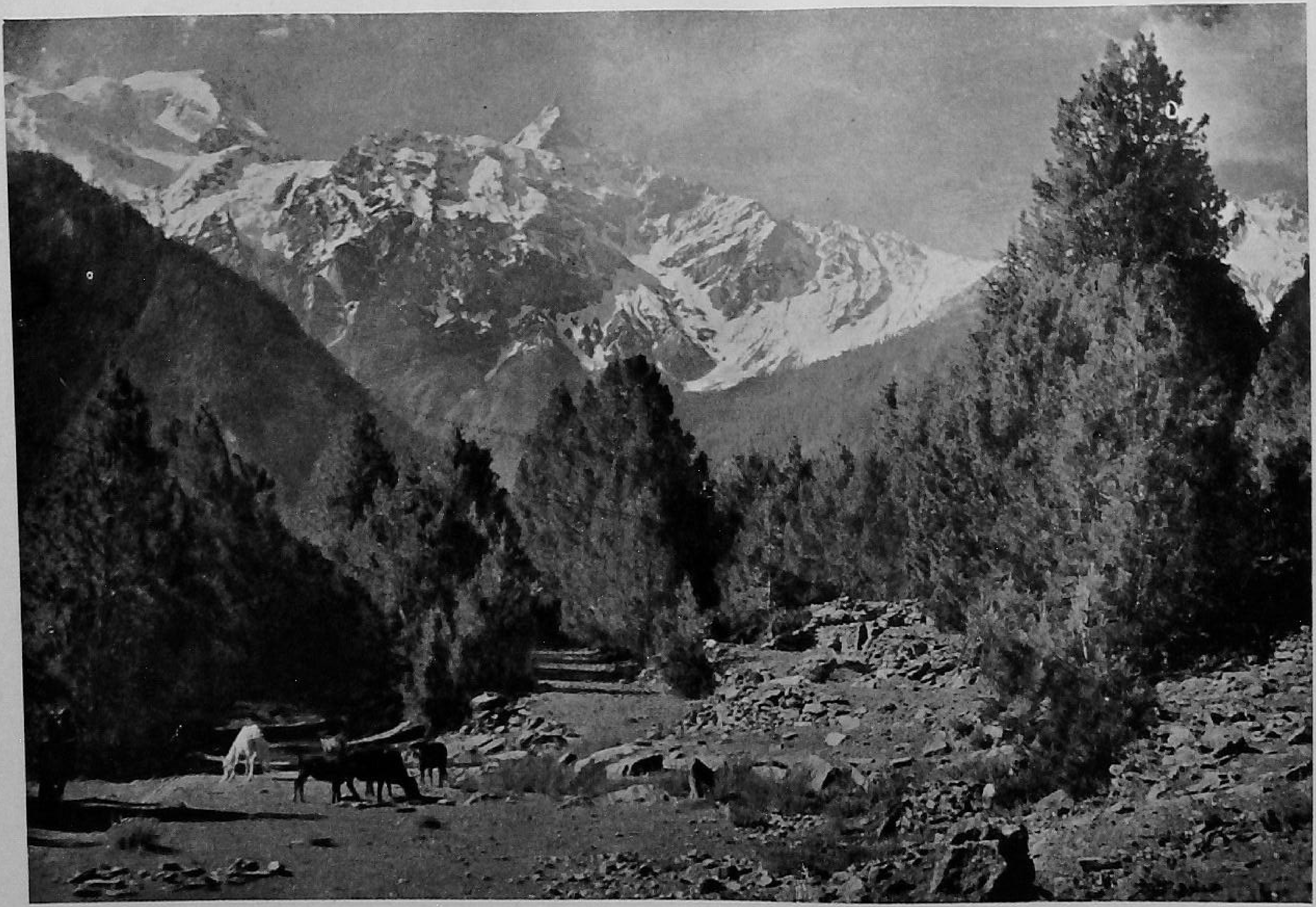
It is always difficult to know what measures to recommend in cases like these. Data on number of livestock, grazing intensities and routes followed are necessary before one can consider adjustments in the grazing practices which might lead to improvement in the grazing and fodder resources. There are few steps which can be taken beyond recommending a limitation of stock numbers and adjustments in routes upward and downward. The building up of reserves of coarse cut fodder from the forests at points along the route to reduce the grazing intensity might be feasible but little forest grass is available for the purpose.

As the control of nomadic and migratory livestock is a major problem to Forest and Anima Husbandry Departments in many other parts of the world, it has been considered appropriate to present here adapted extracts from the Kulu-Seraj and Kangra Working Plans prepared by the Forest Department, Punjab. Further consideration of the question will be found in Chapter XII.

Kulu-Seraj Working Plan

General statistics of population, cultivated area and number of animals grazed during recent years show that there has been a steady increase under almost every item. Population has been rising, mainly in Kulu Waziri proper, which has registered a further rise of 33 per cent in the years from 1931 to 1941; Rupi and

PLATE XXIII



Forest of *Pinus gerardiana* on abandoned cultivated land. Occasional trees of *Quercus ilex*, with undergrowth of scanty, short grass, *Artemisia maritima*, and occasional Bedens.—Upper Bashahr Division, Punjab

Photo: M. V. Laurie

inner Seraj show a slight decrease whereas outer Seraj shows only a slight increase. The area of cultivated land stood unchanged at 83,467 acres in 1940-41.

The number of cows and bullocks increased very rapidly between the years 1871 and 1914. For three years around 1914, the cattle were seriously stricken with rinderpest and foot and mouth disease and were consequently heavily reduced in numbers. From that time onwards the numbers kept fairly steady with a slight general reduction until in 1930 it stood at 70,741. Since then, there has again been a rapid increase to 120, 889 in 1945, i.e. a 70 per cent increase in 15 years. A large fluctuation in the number of sheep and goats may be due to an error in the census figures.

All the protected forests are open to the exercise of grazing rights unless closed by orders of the local Government under section 30 (b) or 66 of the Forest Act. The areas at present closed for regeneration purposes under approval of the Governor in Council are contained in many notifications issued when necessity arose to close the areas concerned. Most of these closures are due to expire and fresh areas will require to be notified for closure according to the prescriptions of the present Plan.

The grazing rights are recorded in a general way, the principle being that a right holder may graze the number of cattle, sheep and goats necessary for his bona fide agricultural and domestic requirements. In practice large flocks are kept for pastoral purposes, although no right to unlimited grazing actually exists. It will not, therefore, be desirable to consider this pastoral grazing too favourably in dealing with closures necessary for the reproduction of the forests, and the grazing of the pastoral flocks of foreign owners can hardly be considered in this connection.

That heavy grazing is inimical to regeneration is fully recognized. It is mainly because of the damage done by grazing that the selection system prescribed in the first Working Plan failed and led to the adoption of the uniform system of management, especially in areas near villages; only a small proportion, usually about a fourth of the whole forest area, is prescribed for regeneration and is closed, whereas the rest of the forest remains open for the use of the right holders. Indeed, under such a system there is no objection to allowing grazing in such portions of the reserved forests as are not under regeneration and are in such a condition as not to be damaged by grazing.

SHEEP AND GOAT GRAZING—*GADDI* FLOCKS

Gaddis (true shepherds) are not allowed to enter Kulu before the 15th *Jeth* (beginning of June). They must enter through one of the three prescribed routes only, namely (1) Sari Pass, (2) Bhabu Pass, and (3) Dulchi Pass.

As the Sari Pass is now closed because of closure of Chhota Banghal against sheep and goats, the main pressure is now on the Bhabu Pass. They must leave Kulu by 20th *Asuj* (beginning of October), by the following prescribed routes:

(1) Kali Hain Pass, (2) Gora Lotinu Pass,
(3) Bhabu Pass, (4) Dulchi Pass.

They cannot halt for more than one night at one place or travel less than five miles a day unless permitted to do so by the Settlement Rules or by a special written order of the Divisional Forest Officer or Sub-Divisional Officer. They enjoy free passage and all go to Lahaul. The grazing dues applied in the Punjab are summarized in Table LXXVII. The *Thakar* of Lahaul collects grazing dues from the *gaddis* at three pies per head, deducts one-fourth of it as his own share and credits the balance to Government as civil revenue.

Buffaloes : The grazing of buffaloes is not permitted under the Settlement. The Forest Officer at his discretion allows a certain number of buffaloes to graze on permits on flat places in undemarcated forests where they can do little harm; provided that permission shall not be given if the right holders in the forest show reasonable and sufficient cause to the contrary. During summer a limited number is allowed to graze in high level thatches of second class protected forests but there is frequently trouble with illicit grazing of a much larger number than permitted. Since August 1947, however, there has been an appreciable reduction in the number of *Gujjar* buffaloes and the problem of introducing additional buffaloes illicitly has eased considerably.

Grazing : Experience had shown that failure to obtain *deodar* regeneration during the currency of the first Plan was primarily due to unrestricted grazing of cattle, sheep and goats. It became obvious that control over such unrestricted grazing was essential before any large scale success could be obtained in regenerating the forests. The areas prescribed for regeneration in the second Plan, therefore, were so selected that they could be closed to grazing in accordance with the Forest Settlement without serious inconvenience to the local inhabitants.

PLATE XXIV

Grazing ground in deodar forest at about 6,000 feet elevation.—Lower Bashahr Division, Punjab

Photo : A. L. Griffith

Grazing, it may be pointed out, is not entirely harmful. Although cattle, sheep and goats harm younger regeneration and cause the soil to harden and to tend to become infertile, they probably do more good than harm in areas subject to heavy weed growth by keeping down the inflammable grass and herbage ; indeed, heavily grazed forests suffer far less damage from fire than forests situated away from hamlets in which there is little grazing. Light grazing also helps regeneration to establish which would otherwise be smothered by weeds. In areas where grazing is heavy, however, the seedlings are constantly browsed by sheep and goats ; and grazing does retard for a long time or may even prevent regeneration on hot southern slopes. There is also no doubt that in plantations the successful introduction of *deodar* depends largely on the closure of the plantation to grazing and browsing for the first few years.

In fir forests, grazing assumes very great importance because of its inhibiting effect on regeneration, especially when the incidence is heavy. Since many of these forests lie along migratory routes of *'Gaddi'* flocks, grazing in such areas is almost exclusively responsible for the absence of all regeneration. A study of fir forests along migratory routes and near large villages in Upper Kulu has shown that this incidence of grazing has increased considerably during the last 40 to 50 years. For example, around Manali with its large local population of sheep and goats and thousands of migratory animals going to and returning from Lahaul, passing near these forests, the absence of fir regeneration in the lower parts of the forest can be entirely attributed to very heavy grazing incidence. On the other hand, in damper parts away from sheep and goat runs, light grazing often helps in promoting natural regeneration of the firs by keeping down the weeds and by reducing the factors of the locality just sufficiently to help regeneration to begin.

The huge influx of migratory flocks is reflected in serious slips along the main roads, especially between Kulu and Manali. The fact that this influx occurs during April/May when the flocks move on their way up, and again in September and October when they move down from alpine pasture in Lahaul is closely related to this damage, since in both these periods the vegetation on the ground is scanty and hence the damage greater. These *gaddis*, according to rules, are permitted to move five miles a day and cannot stay for more than one night within this distance except under special circumstances ; between Raison and Manali, this provision is more honoured in the breach under cover of the clause

permitting them to stay for manuring local fields. They do much more damage during halts than they do while marching ; flocks move up to four to five miles radius from their pens, whereas while on the march they do not go beyond a radius of about a mile.

This incidence has recently increased still further in certain specified places, due to the influx of flocks and ponies of Lahaulas. They have in particular increased along the main valley between Kulu and Manali, as is reflected in the still more serious slips along the motor road. Unless the problem is solved satisfactorily, the road is doomed. Being really '*Khanabadosh*' and non-right-holders they can and should be excluded, but the Forest Department has no jurisdiction in interfering with such grazing unless the local right-holders complain. These latter can, however, generally be easily quietened by a little money to the more influential inhabitants or by the supply of manure from their flocks for the fields.

Kangra Working Plan

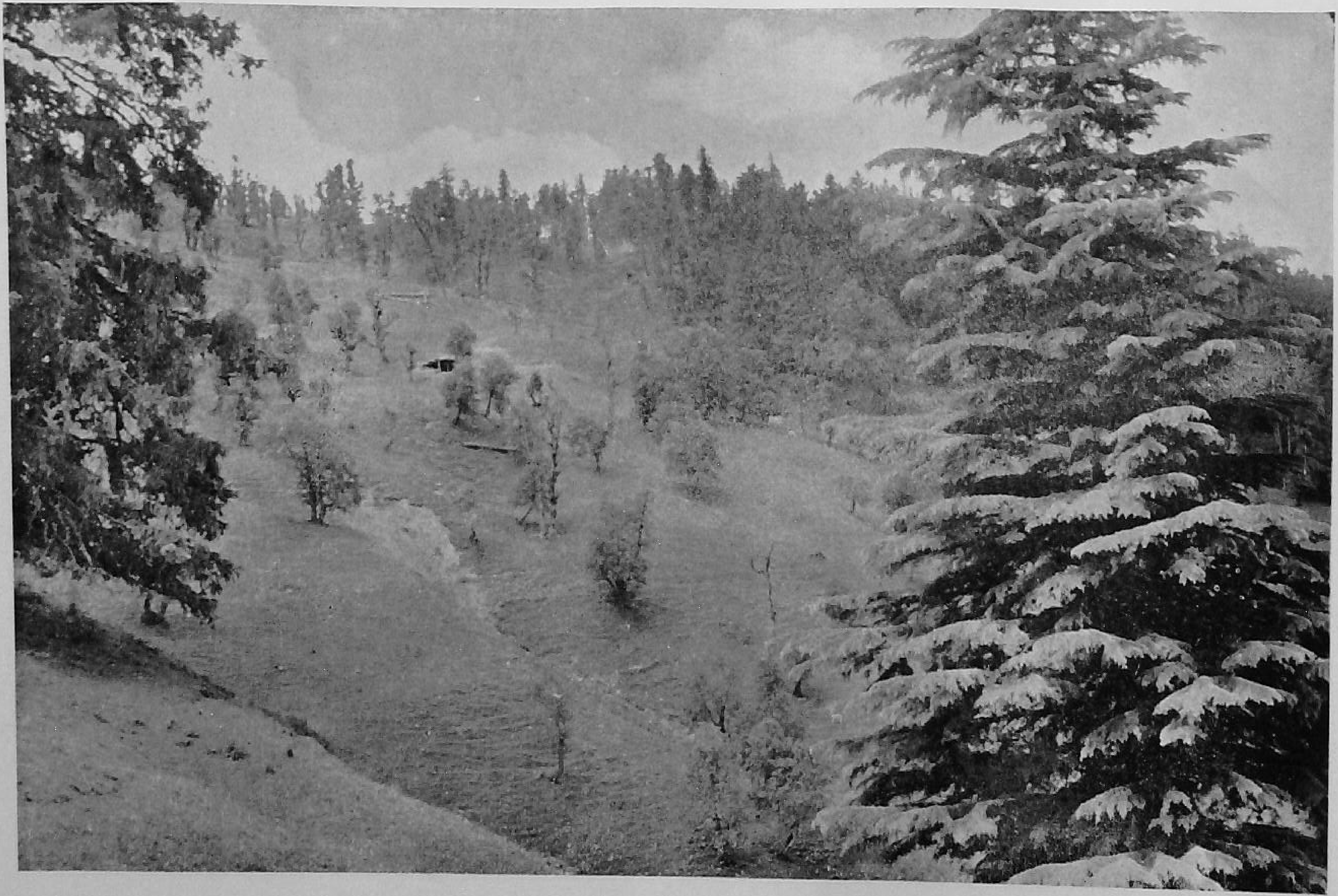
Gaddi *Grazing* :—The *Gaddis,* who generally belong to Chamba but in some cases have purchased land in Kangra to become entitled to all the rights of user, are true shepherds. The rich pastures on the southern slopes of Dhaula Dhar provide autumn and summer grazing for four to five months ; for three to four months in the winter, the flocks resort to recorded 'runs' in the low hills which afford insufficient and poor grazing ; in the rainy season the *Gaddis* take shelter behind the main range by moving to Bara Banghal, Chamba and Lahaul, where very fine grazing is available in the high alpine pastures.

The movements of flocks are governed by the following rules :

(i) Two classes of *Gaddis* have to be recognized and they pay (1951) at the rates detailed below :

Class	In areas where they graze as land owners	Bara Banghal	Dhaula Dhar	Low hills
Residents	Cattle tax to Revenue Authorities	Sheep Rs. 1/9/- per hundred Goats Rs. 1/9/- per hundred	Sheep Rs. 7/13/- per hundred Goats Rs. 25/- per hundred	Same rates as in Dhaula Dhar
Migrants	......	Sheep Rs. 7/13/- per hundred	-do- (if they halt to graze, otherwise none)	-do-

PLATE XXV



Overgrazed thatch in oak/ fir forest now carrying only inedible *Prunus padus*.—Chakrata Division, Uttar Pradesh.

Photo : H. G. Champion

Note: These rates are the increased rates (Punjab Government letter No. 1960 Fot., dated the 20th November 1945). The original rates were Rs. 4/11/0 per hundred sheep and Rs. 15/10/0 per hundred goats. This increase in the grazing dues was made to reduce the number of sheep and goats in the district with a view to saving the forests from destruction.

(ii) For purposes of enumeration lambs and kids born in the spring are counted.

(iii) Daily stages must be five miles apart.

(iv) No halt may ordinarily be made for more than one night at any halting place, but when delayed by rain or by necessity of giving salt to the flocks, a halt for two nights is allowed. If these limits are exceeded, a halting fee equal to the full grazing fee is leviable but the Deputy Commissioner has discretion, in special cases, to reduce it in case of goats to not less than Rs. 4/11/0 per hundred. He has ruled that the halting fee of Rs. 4/11/0 per hundred should be charged for halting for more than two days but less than six days, unless the halt is for manuring the fields of the right holders when no fee is leviable, Rs. 6/4/0 per hundred goats and Rs. 4/11/0 per hundred sheep if the stay, exclusive of days allowed for manuring, exceeds nine days but does not exceed 15 days. No flocks are permitted to halt at a place for more than 15 days. The period for halting for manuring should not exceed three nights at one place and halting fee is leviable for excesses even if the halt be for manuring purposes.

(v) In spring a halt of three weeks in the higher ranges in excess of the period actually necessary for the journey across the passes is permitted.

(vi) No halting fee can be charged for halting in *tikas* where *gaddis* own land and are thus ordinary right-holders, provided they confine their grazing to the forest in which they have rights as owners of land.

(vii) *Gaddis* and the *zamindars* must make their own arrangements in regard to manuring fields, but the *zamindars* may not interfere with the *gaddis* even though they refuse to manure (except in Kaniyara and Narwana where, by custom, the *zamindars* can claim manure in return for grazing).

The grazing dues (*Tirni*) have during the three recent years yielded an annual average income of Rs. 50,251.

Gujjar *Grazing* :—*Gujjars* are of two classes: '*Ban Gujjars*' and '*Sawanadars*'. The former were originally nomads or residents, the latter are invariably permanent residents of the district and generally co-proprietors of the villages, and have *Sawanas* or *Dhars* recorded in their names which can change hands only by inheritance.

The *Sawanadar Gujjars* may graze their cattle in the *Sawanas* recorded in their names to the exclusion of cattle of all other right holders during the three or four months of monsoon. The '*Ban-Gujjars*', on the other hand, have no recorded rights anywhere in the district but the right holders in *tehsil* Nurpur and *mauza* Boh of *tehsil* Kangra who have recorded rights to invite *Ban-Gujjars* to their grazing grounds may permit them to graze one horned cattle on payment of certain fees.

Rajasthan

The problem of nomadic animal husbandry is not so acute in the State of Rajasthan as it is in the Kulu and Kangra Valleys, where the migration to summer pastures is a regular annual occurrence. Such migration may be of frequent occurrence in Rajasthan, but it does not necessarily happen every year or in fixed periods of the year. A great part of western and northwestern Rajasthan is more pastoral than agricultural. The rainfall is low and often uncertain, there is a scarcity of fodder in cycles of five or six years. From such areas, an exodus of cattle takes place in years of famine and scarcity in search of grazing to other parts of Rajasthan, and to Madhya Bharat, Uttar Pradesh and sometimes Bombay State, more favourable areas in which it is stated that surplus pasturage is available.

The following routes are usually taken:

(i) Cattle from Jodhpur, Pali, Nagpur districts cross Jodhpur Division and pass through Nasirabad to :

(a) Deoli-Bundi-Kota-Jhalawar and Bhopal, or

(b) Chitorgarh-Mandsaur-Indore

(ii) Cattle from Kishengarh and adjoining parts of Jaipur Division pass through Nasirabad and follow either of the two routes mentioned under (i) above

PLATE XXVI

Alpine pasture at 8,500 feet in Gahan Block. The tree growth is fir, spruce, maple and chestnut.—Lower Bashahr Division, Punjab

Photo : A. L. Griffith

(iii) Sheep and goats very often pass through Bharatpur, Agra, and find pasturage in the Indo-Gangetic plain.

The Chief Conservator of Forests, Rajasthan, states that the spasmodic migration of cattle into other parts of Rajasthan or into adjoining States is not due to scarcity of available pasturage alone. The scarcity in bad years could easily be met by building up fodder reserves during good years. The main problem is, however, scarcity of water and unemployment in bad years. It is stated that Rajasthan abounds in grasslands and the surplus in good years could easily be stored as famine insurance. Until, therefore, the problem of availability of water is successfully solved, the migration of cattle will continue as a matter of sheer necessity.

A Forest Experiment Station has been established at Jodhpur in Rajasthan to study all possible methods for the revegetation of the desert and near-desert areas of the State. A careful study and survey of these areas would show, however, that protection of the existing vegetation against damage from grazing of cattle and more particularly browsers is more important and economic than measures for revegetation. Efforts should, as in all desert and semi-desert reclamation projects, be directed in the first instance to conserving whatever vegetation already exists.

Para 12 of National Forest Policy, (Government of India, 1952) reads as follows:

"*The immobilization of the desert of Rjaputana (i.e. Rajasthan).*

Attention also needs to be drawn here to the Rajputana desert, more particularly to the fixation of the shifting sand dunes. Strong winds that develop in this region during the summer transport vast quantities of sand and salt from the sea and Rann of Cutch, whipping the desert into terrific dust storms, the fury of which is felt throughout north western India. The desert has spread through the ages, causing the 'westering' of the Indus and the 'northering' of the Sutlej, meeting an obstruction of sorts only along its eastern confines in the Aravallis. The immobilization of the desert and protection of the remaining fertile belts inside it constitutes one of the planks of the National Forest Policy."

It is expected that the Second Five-Year Plan will contain provision for extensive work on the conservation of vegetation and soil on the so-called Rajasthan "desert". This area is defined as covering some 80,000 square miles, not only in the State of Rajasthan itself, but also in Kutch, Saurashtra and Bombay

in the south and west, Uttar Pradesh in the east and Punjab and PEPSU in the north. The problem to be faced is not one of afforestation alone, but also of the proper utilisation of land and the optimal conservation of vegetation, soil and water. The principal initial causes of the desertic conditions in Rajasthan are the indiscriminate felling of trees for fuel, fodder and other purposes, and over-grazing. Too much blame should not, therefore, be accorded to the grazing animals, even though their numbers may be in excess of the carrying capacity of the grazing lands. A factor of at least equal importance as a cause of soil instability in these hot, dry areas is the annual cultivation which takes place for the production of one rain-fed crop. After this crop has been harvested, the soil is left bare, denuded of any protective cover or humus and at the mercy of the elements.

In sparsely populated areas such as Jaisalmer Division, where cropping is not practised, there is a substantial cover of vigorous grasses, which do not appear to be destroyed by heavy grazing, except in the immediate vicinity of villages and watering places where trampling is severe. Again, in the northern part of the State, the soil immediately along the roadsides, and sometimes on Community grazing lands, is often held by the fibrous root systems of the grasses, despite gross over-grazing, whereas cultivated areas immediately adjacent are sandy and completely unstable (Personal communication from P. R. McMahon, F.A.O Sheep and Wool Expert, Jaipur, 13 March 1956).

Improved cropping systems should, therefore, also be investigated in the new development programme, to restore soil structure and reduce erosion. Areas marginal for crop production should also be retired to a grass cover whenever possible.

According to the scheme prepared for inclusion in the Second Plan, expenditure on the Desert Afforestation Research Station at Jodhpur and its extension activities will be met by the Government of India. The scheme also provides for assistance from the Central Government for the development of tree planting areas and pastures. If villagers or co-operative societies help in establishing shelter-belts along the boundaries of their villages or fields by freeing strips of land permanently for trees or pastures, the expenditure they incur may be reimbursed on the basis of : State 25 per cent, Centre 75 per cent.

Uttar Pradesh

The Government of Uttar Pradesh is undertaking a great scheme for the planting of a long shelterbelt zone, to protect the valuable lands of the Gangetic

PLATE XXVII

Forest of *Picea morinda* open to grazing and showing absense of all undergrowth.—Jaunsar Division, Uttar Pradesh

Photo: B. O. Coventry

Plain from the disastrous desiccating effects of the dry desert winds which blow dust-laden from the west out of Rajasthan. But Uttar Pradesh has serious problems of its own, as described by Sen (1954).

Uncontrolled nomadic free-range grazing of large flocks of goats and sheep in Jaunsar-Bawar and Tehri Garhwal by the *Jaunsaris* and in Almora district by the *Bhotias* has already made the natural regeneration of high level forests (coniferous and broad-leaved) almost impossible. Problems of water and soil conservation are becoming more acute every day. As specific routes are prescribed for *Bhotia* flocks, these problems are more acute along such routes.

The free-range grazing of large flocks of goats in the Jamuna-Chambal ravines of the State along the tract bordering Rajasthan in the Agra and Mathura districts is helping the rapid onward march of the desert. As the little grazing that is available during the rains is very soon exhausted, the herdsmen resort to indiscriminate lopping of trees, leaving behind a trail of destruction of tree crops ; soon nothing but worthless shrubs are left.

Attempts to limit the number of the grazing flocks by enhancement of grazing fees have been made from time to time, but on every such occasion protests have been so effective that little has been achieved.

Migratory herds of buffaloes of the '*Gujjars*' and the migratory hillmen have been and still are responsible for the rapid destruction of the valuable miscellaneous forests of the foothills of the Himalayas. The unstable hill streams (*raus*) are rapidly extending their banks, causing destruction of valuable agricultural land further down.

In the hills of Kumaun and Garhwal where grazing of village cattle is free, the number of cattle has increased to such an extent that little grazing is now available and people have to resort to indiscriminate lopping of trees with the consequence of rapid destruction of loppable species and ultimately of the tree cover, leaving landslips in its wake.

Rehabilitation of Nomadic Cattle Breeders

There are in India over twenty thousand families of nomadic cattle breeders who maintain about 8 to 10 million cattle and provide working bullocks and ghee of considerable value in the national economy. These cattle are maintained largely on grazing lands under a system of seasonal migration. During recent decades, the condition of these breeders has become difficult in some

tracts. Due to the inadequacy of the grazing land, their herds have decreased in number and the cost of production has increased. Many families have been forced for economic reasons to leave their hereditary profession and work as labourers in rural and urban areas. There is also an increasing incidence of damage to cultivated crops by the producers of cattle.

These breeders are excellent husbandmen and possess great traditional knowledge of cattle, animal husbandry, grazing areas and grasses, cattle ailments and their treatment, and they face without complaint great hardships to maintain and preserve their herds during difficult periods. In spite of many difficulties, they have done their best to supply bullock power and preserve the cattle wealth of the country through recurring famines.

The Government of India now realises that it is necessary to rehabilitate the economy of these breeders and to enable them to improve their cattle husbandry and to develop superior types. Such professional cattle breeders are found in a number of States : Bombay, Rajasthan, Kutch, Andhra, Hyderabad, Madhya Pradesh, Madhya Bharat, Uttar Pradesh, Punjab and Himachal Pradesh. A scheme for this rehabilitation has been included in the Second Five-Year Plan

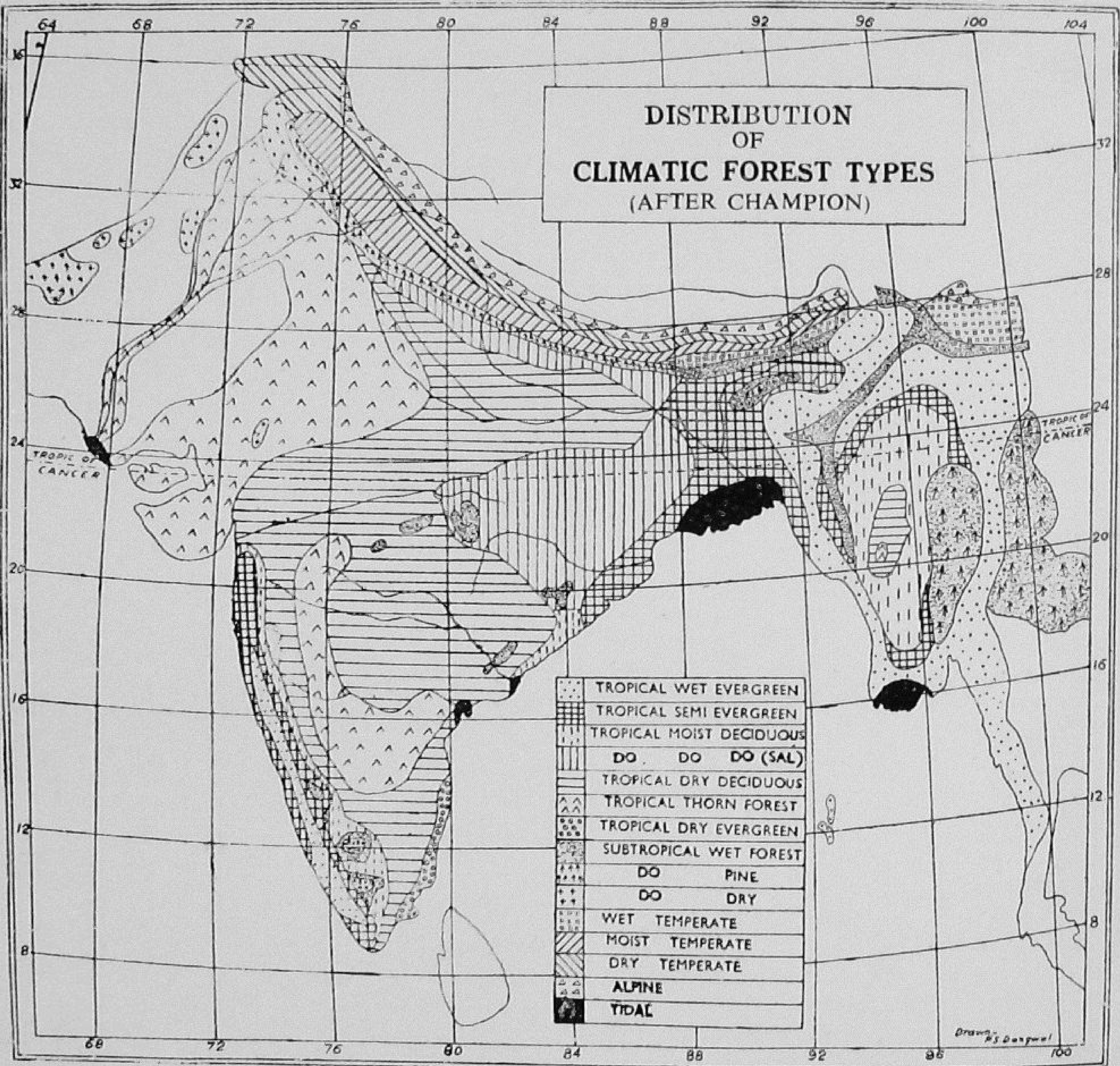

DISTRIBUTION
OF
CLIMATIC FOREST TYPES
(AFTER CHAMPION)
TROPIC OF CANCER
TROPICAL WET EVERGREEN
TROPICAL SEMI EVERGREEN
TROPICAL MOIST DECIDUOUS
DO. DO DO (SAL)
TROPICAL DRY DECIDUOUS
TROPICAL THORN FOREST
TROPICAL DRY EVERGREEN
SUBTROPICAL WET FOREST
DO PINE
DO DRY
WET TEMPERATE
MOIST TEMPERATE
DRY TEMPERATE
ALPINE
TIDAL

Fig. 14

CHAPTER XI

GRAZING IN FORESTS

GOVERNMENT forests, which comprise mainly the reserved forests, are beyond the reach of an overwhelming majority of the livestock in India. In 1947-48, 24.6 million cattle are estimated to have resorted to Government forests for grazing. As this is only 11.2 per cent of the cattle population, the place of forests in meeting the grazing needs of the country is secondary. Yet forests are important locally as sources of fodder and grazing, and grazing is, in fact, a perpetual problem in forest management.

The percentage of forest-going cattle in relation to total cattle population varies considerably from State to State, from a minimum of 0.05 per cent in West Bengal to a maximum of 94.5 per cent in Jammu and Kashmir (Table LXVIII). The following factors are important in influencing the extent to which cattle use forest grazing in India.

Relative proportion of forest area to total area of States

Speaking generally, one might expect that the States with the largest areas of forests should provide more grazing and that more cattle would seek forest grazing in them. True, Madhya Pradesh, Himachal Pradesh, Tripura and Vindhya Pradesh have relatively large areas under forest and are also characterized by large populations of forest-going cattle. Assam, Travancore-Cochin and Coorg have vast forest areas, yet support relatively few cattle. Punjab and Jammu and Kashmir have little Government forests but support large cattle populations. Obviously other factors are at work. If forests are not distributed uniformly over a State, their accessibility to and use by cattle from different parts become restricted. Cattle are grazed in forests either when there is no grazing outside the forest, or when the forest grazing is better than other grazing in the vicinity. Assam, Travancore-Cochin, Coorg and West Bengal have for the most part superior types of forest in which grass, and particularly grass of fodder value, is scarce.

Existence of private forests

The existence of such forests, particularly nearer the villages, will tend to reduce the grazing pressure on Government forests considerably, because these

forests have fewer restrictions, often provide cheaper grazing and so are more attractive to owners of cattle. Bihar, Madhya Pradesh, Madras, Coorg and Ajmer have considerable areas of non-Government forests which relieve the grazing burden on the Government forests themselves.

Accessibility of forests

As cattle have to be brought back every evening for shelter, they cannot graze more than four or five miles from their stations. Forests which are distributed throughout a State are more liable to be grazed than those far from habitations, or with steep and inaccessible terrain. The Government forests of Madhya Pradesh, Bhopal, Vindhya Pradesh and Himachal Pradesh have relatively few inaccessible tracts and are, therefore, characterized by fairly widespread grazing.

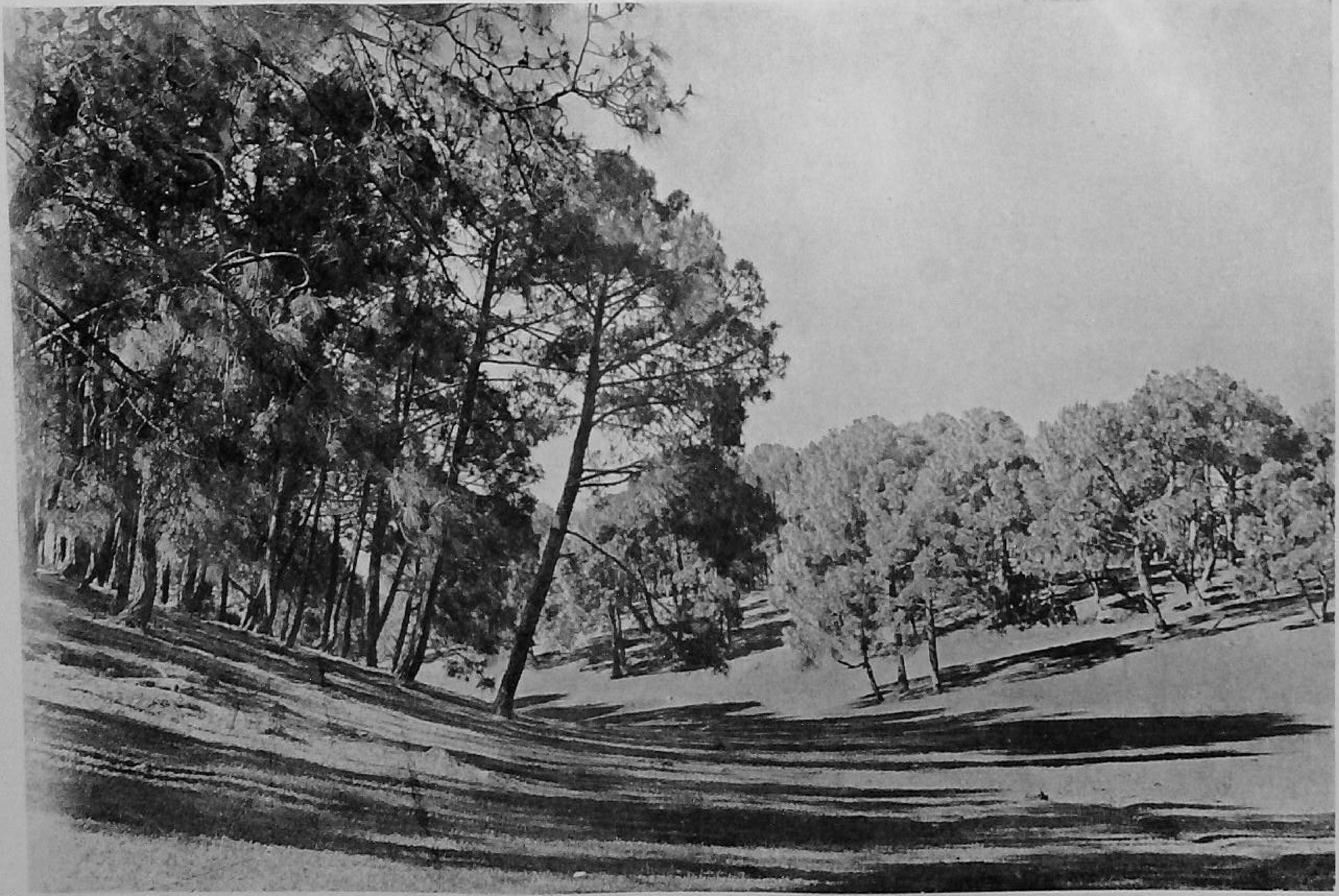
The figures given in column 7 of Tables LXVIII and LXIX are intended to indicate degree of inaccessibility. Unprofitableness is generally a consequence of being too far removed from markets to permit of economic exploitation of forest products. As such, figures of unprofitable or inaccessible forests indicate areas which preclude access for physical or economic reasons. An exception should, however, be made for some forest areas in the Himalaya, e.g. the Kangra and Kulu Districts of the Punjab. Here, habitations extend at short intervals to altitudes of 10,000 feet or more, and grazing and cultivation are practised on unusually steep slopes. Though many such areas are unprofitable for timber extraction, they are subjected to quite heavy grazing.

Timber forests

The better forest areas are generally used for timber production. Generally speaking, grasses are conspicuous in forests under conditions which normally inhibit the production of the best timber (Anon, 1937) or the attainment of a woodland climax. The grass which one may find in *sal* and teak forests is generally of indifferent quality. In the moister *sal*, teak and mixed deciduous forests, the under-growth is predominantly evergreen shrubs with little grass. Even where grass does occur, regular grazing is out of the question so long as timber growing remains the primary objective. This also applies to protection forests which are not managed for timber production but nevertheless carry dense tree growth, such as the wet evergreen climax forests.

Other factors such as quality of grazing or watering facilities for livestock

PLATE XXVIII



Forest of *Pinus longifolia*, of rather poor quality, showing complete absence of natural regeneration due to excessive grazing.—Kangra Division, Punjab

Photo: R. S. Troup

might be considered independently, but attention is here confined to those factors which may permit of a certain amount of quantitative study. In Table LXVIII, these factors are represented in column 5 to 8, and serve within their limits to explain and qualify the values given in column 4. With little competition from private forests, very little inaccessible area, and a greater extent of forest area than some other States, West Bengal yet supports a negligible proportion of cattle in its forests, presumably because they are of little grazing value. This is supported by the figure showing that 99.9 per cent of these forests are devoted to timber production. Similar consideration may be given to most of the values in column 4. In the Punjab, for example, with an inadequate forest area, no private forests, and a high proportion of the accessible forest set apart for timber growing, grazing incidence is quite high. It is in fact the highest in India, 0.9 acre per animal, although only 27 per cent of its cattle population resorts to forest-grazing.

In the year in question, 1947-48, 24.7 million cattle grazed in 117,489 square miles of forests under the control of the Forest Departments, or 3.1 acres per animal for the country as a whole. The position naturally varies widely from State to State, from 0.9 acre per animal in the Punjab to 178.8 acres per animal in Assam (see Table LXIX). Here again the factors referred to above may be used to explain and qualify the values for grazing incidence (see column 5 to 8 in Table LXIX). Generally speaking, a higher proportion of forest area may suggest a lower grazing incidence, the existence of private forests may reduce the grazing incidence in Government forests, and a high proportion of inaccessible area nominally open but not actually subject to grazing may indicate an actual incidence on the accessible areas far above the normal. The very low grazing incidence in Assam, West Bengal, Travancore-Cochin and Coorg is accounted for by the fact that the great majority of their forests, shown as open to grazing, carries timber but no grass, and a good part is also inaccessible ; the peripheral areas to which grazing is confined must, therefore, be carrying a very heavy grazing burden.

Grazing in forests becomes a serious problem because of the nature of its distribution. The total forest area open to grazing includes dense timber tracts with little real grazing, rocky outcrops, blanks, inaccessible slopes and large areas utterly remote from all habitation and cultivation. Grazing is confined largely to the fringes of the forests, bordering villages and around sources of water in the

TABLE LXVIII

Statement showing the proportion of cattle and other animals resorting to forest grazing in Government forests in each State

State	Total population of cattle and other animals (other than pigs)	Number of cattle and other animals permitted to graze in the forests under the control of the Forest Depts.	Number in col. 3 expressed as a percentage of No. in col. 2	Explanatory Data			
				Area of Government forests expressed as a percentage of total area of State	Area of private and other forests expressed as per cent of total State area	Percentage of Government forests considered unprofitable or inaccessible	Percentage of merchantable forest area dedicated to timber production
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Assam	5,466,866	60,244	1.1	24.6	1.2	78.2	93.3
Bihar	18,380,179	329,161	1.8	3.7	14.7	32.1	95.5
Bombay	22,403,712	2,383,684	10.6	12.4	0.2	44.4	87.7
Madhya Pradesh	17,594,592	3,464,513	19.7	14.9	16.5	Nil	96.0
Madras	40,057,752	2,026,700	5·0	14.7	11.6	45.9	36.5
Orissa	11,070,199	263,034	2.4	4.3	3.2	62.9	25.0
Punjab	10,080,013	2,718,647	27.0	10.4	-nil-	83.6	87.6
Uttar Pradesh	38,784,228	1,768,812	4.6	16.1	3.2	35.9	74.4
West Bengal	12,239,875	5,641	0.05	8.8	5.2	0.1	99.9
Hyderabad	17,993,558	1,236,624	6.9	11.5	...	...	...
Jammu and Kashmir	5,409,498	5,126,400	94·7	11.9	...	80.6	...
Madhya Bharat	8,809,852	...	...	...	...	...	...
Mysore	8,592,870	272,320	3.2	15.0	0.4	30.8	81.3
PEPSU	3,325,791	...	...	1.0	1.4	...	63.6
Rajasthan	26,554,080	...	...	...	...	...	...
Saurashtra	1,051,018	89,982	8.6	2.9	-n	4.8	-nil-
Travancore-Cochin	1,780,145	33,172	1.9	33.5	-nil-	24.5	91.1

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ajmer	958,374	12,564	1.3	3.0	21.5	...	Nil
Bhopal	929,561	237,245	25.5	17.6	5.0	...	100.0
Bilaspur	144,140* *(The figures are obviously wrong)	184,492*	...	44.1	...	75.5	26.5
Coorg	142,409	20,355	14.3	52.6	20.	37.5	71.2
Delhi	251,399	...	...	...	...	...	...
Himachal Pradesh	2,296,352	1,932,553	84.2	27.4	...	22.5	85.2
Kutch	1,068,365	...	...	...	...	...	...
Manipur	166,918	...	...	. .	...	...	...
Tripura	232,953	79,738	34.2	89.6	...	50.0	20.0
Vindhya Pradesh	1,545704	1,096,749	24.1	33.9	...	25.0	33.3
Andamans	...	...	...	77.8	...	...	93.1
Total excluding States for which full data are not available	220,009,858	23,342,630	11.2				

Note : 1. Figures in Col. 2 were derived from Table No. XI of '*Abstract of Agricultural Statistics, 1950*' published in 1952.

2. Excepting in the case of the Punjab, Figures in Col. 3 are from Col. 22 of Statement XIX of '*Indian Forest Statistics*, 1947-48' published in 1952. In the case of the Punjab, this publication gives the figure as 4,170,386 which is about 2 million more than the previous years' figure and is obviously wrong. The figure now given is derived from the *Punjab Forest Administration Report for 1948-49* and accords with the figure for 1946-47 also.

3. Figures in Col. 5 were worked out using figures in Col. 5 of Statement I and figures in Col. 2 of Statement '*Indian Forest Statistics*, 1947-48'.

4. Figures in Col. 6 were worked out using figures in Col. 6 & 7 of Statement I and those in Col. 2 of Statement of '*Indian Forest Statistics*, 1947-48'.

5. Figures in Col. 7 were worked out using figures in Col. 5 of Statement I and total forest areas given in Col. 6 of Statement II of '*Indian Forest Statistics 1947-48*'. In the case of U. P., however, there were discrepancies between statements I and II and so unprofitable area was assumed as the difference between total area in Col. 6 of Statement II and merchantable area shown in Col. 5 of Statement I.

6. Figures in Col. 8 were worked out using figures in Col. 3 and Col. 5 of Statement I of *Indian Forest Statistics. 1947-48*'.

7. Particulars of grazing animals are available for all Government forests together but not separately for reserved forests or for forests under the control of the Forest Department. (Vide Statement XIX of *Indian Forest Statistics, 1947-48*).

8. With reference to data given in the "*Report of the Preliminary Conference on the better utilization of forest areas for grazing*". *1937*, based on the census figures for 1935, the percentages of cattle and other animals grazing in 1935 work out as follows :

U. P.	2.9 per cent	Punjab	10.6 per cent	Bombay	17.4 per cent
Madras	5.1 per cent	Central Provinces	19.2 per cent		

Table LXIX

Grazing incidence in forests under the control of Forest Department in each State

State	Net area of forests under the control of Forest Department open to grazing (sq. miles)	No. of cattle and other animals permitted to graze in the area in Col. 2	Grazing incidence expressed as No. of acres per animal	Explanatory Data: Area of forests under the control of Forest Department expressed as a percentage of total area of State	Explanatory Data: Area of private and other forests expressed as a percentage of total area of State	Explanatory Data: Percentage of Government forest considered unprofitable or inaccessible	Explanatory Data: Percentage of merchantable forest area dedicated to timber production
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Assam	16,831	60,244	178.8	24.64	1.2	78.2	93.3
Bihar	2,024	329,161	3.9	3.39	14.7	32.1	95.5
Bombay	10,758	2,383,684	2.9	10.60	0.2	44.4	87.7
Madhya Pradesh	17,478	3,464,513	3 2	14.91	16.5	-nil-	96.0
Madras	14,242	2,026,700	4.5	12.45	11.6	45.9	36.5
Orissa	2,397	263,034	5.8	4.78	3.2	62.6	25.0
Punjab	3,688	2,718,647	0.9	10.37	-nil-	83.6	87.6
Uttar Pradesh	8,654	1,768,812	3.1	9.00	3.2	35.9	74.4
West Bengal	167	5,641	19.0	8.68	5.2	0.1	99.9
Hyderabad	6,772	1,236,624	3.5	11.52	...	...	...
Jammu and Kashmir	10,525	5,126,400	1.3	11.92	...	80.6	...
Mysore	4,344	272,320	10.2	15.07	0 4	30.8	81.3
PEPSU	(198)	..	...	(2.36)	1.4		63.6
Saurashtra	603	89,932	4.3	2.94	-nil-	4.8	-nil-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Travancore-Cochin	2,874	33,172	55.4	33.52	Nil	24.5	91.1
Ajmer	37	12,564	1.9	3.02	21.5	...	Nil
Bhopal	1,177	237,245	3.2	17.69	5.0	...	100.0
Bilaspur	(193)	..	...	(44.15)	...	75.5	26.5
Coorg	815	20,355	25.6	52.58	20.9	37.5	71.2
Himachal Pradesh	2,784	1,932,553	1.0	27.38	...	22.5	85.2
Kutch	(156)	...	...	(0.93)	...	...	...
Tripura	3,610	79,738	29.0	89.53	...	50.0	20.0
Vindhya Pradesh	7,709	1,096,749	4.5	33.39	...	25.0	33.3
Andamans and Nicobar	...	...	..	(68.09)	...	...	93.1
Total excluding States for which full data are not available	117,489	23,342,630	3.1				

Note: 1. Figures in Col. 2 were derived as the difference between figures in Col. 6 of statement II and those in Col. 2 of statement X of '*Indian Forest Statistics, 1947-48*' published in 1952.

2. Excepting in the case of the Punjab, Figures in Col. 3 are from Col. 22 of Statement XIX in above publication. In the case of the Punjab, this publication gives the figure as 4, 170, 386, which is about 2 million more than the previous year's figure and is obviously wrong. The figure now given is derived from the *Punjab Forest Administration Report for* 1948-49 and accords with the figure for 1946-47 also.

3. Figures in Col. 5 are from Col. 7 of Statement II of *Indian Forest Statistics* 1947-48

4. Figures in Col. 6 were worked out using figures in Cols. 6 and 7 of statement I and those in Col, 2 of statement of above publication.

5. Figures in Col. 7 were worked out using figures in Col. 5 of statement I and total forest areas given in Col. 6 of statement II of above publication.

6. Figures in Col. 8 were worked out using figures in Col. 3 and Col. 5 of statement I of above publication.

7. Forests under the control of other departments and corporate bodies and private individuals are not included in the statement. The Statement includes, however, forests other than Reserved forests' under the control of the Forest Departments.

8. Particulars of grazing incidence given in "*Report of the Preliminary Conference on the better utilization of forest ar as for grazing*", 1937, based on the livestock census of 1935 were :

	acres per animal
United Provinces	2
Madras	4
Punjab	1.1
Central Provinces	3.5
Bombay	3.25

interior where cattle may be penned. Grazing incidence may be inordinately high at these places and negligible elsewhere. The heavily grazed areas are frequently of the scrub or thorn-forest type, highly susceptible to damage. Overgrazing results in the depletion of the more palatable and nutritive grasses and in general denudation and deterioration of resources. The policy of cheap or free grazing has encouraged the promiscuous breeding of uneconomic scrub cattle in the villages bordering the forests ; the grazing incidence has, therefore, increased and so also the damage to the grazing grounds. The control and regulation of forest grazing are essential if it is to be improved in quality and quantity, and is to remain a permanent asset.

With hardly any effective management of grazing being possible in most of the forest areas under the administration of Forest Departments, the conditions in other forests and waste lands (Government or private) can well be imagined. Their management is generally vested in the State Revenue Departments, and there is usually no restriction on the number or type of livestock grazing in them. Goats are generally excluded from reserved forests but are permitted to browse in those under the control of the Revenue Department. There is actually no effective restriction either on grazing or the illicit exploitation of tree growth. As a result, these waste lands, which are usually communal lands set aside to meet the local demands for fuel, small timber and grazing, have deteriorated so much that more and more of these requirements are being obtained from the reserved forests themselves (Krishnaswamy, V. S. and Venkataramana Reddy, 1953).

Compatibility of forestry and grazing

In certain circumstances, a moderate amount of grazing does little harm to forests, and may in fact be definitely indicated as a fire-protection measure. Grazing in association with other biotic factors has often an important role to play in arresting ecological succession in forests and maintaining them at an economically valuable stage. In scientific forestry, therefore, grazing is employed as a regular silvicultural technique in certain conditions. It is, therefore, not correct to say that forestry and grazing are incompatible, although unlimited or uncontrolled grazing has no place in forest management. Forest grazing, like forests fires, is a good servant but a bad master.

Next to fire, grazing is probably the most influential factor governing the distribution of forest types and, like fire, is to be considered as a useful aid to natural regeneration. It helps to reduce undergrowth, expose mineral soil and

PLATE XXIX

Preservation plot in *Pinus longifolia* forest, with chir pole and sapling crop forming more or less complete canopy, on old village terraces.—Garhwal Division, Uttar Pradesh

Photo : E. C. Mobbs

mix it with humus, and trample the seed into the soil. Grazing helps to remove excessive grass growth and so reduces the fire hazard.

Well-distributed controlled grazing of *sal*, *chir* pine and *deodar* forests has been known to promote regeneration. Teak is not usually browsed; grazing reduces the competitors and enables the trees to grow better (Champion and Griffith, 1948). Ranganathan (1934) has drawn attention to the importance of grazing in the ecology of the valuable sandalwood forests, by keeping down the inflammable grass and so protecting the extremely susceptible trees from fire. Rowntree (1940) has recommended heavy grazing in areas where *sal* regeneration is difficult; if grazing is limited to the winter months, the regeneration of *simul* is greatly encouraged in parts of Assam (Rowntree, 1937). Fairly heavy grazing in certain waste lands in Coorg has resulted in profuse regeneration of *Pterocarpus marsupium* and teak (Coorg, Forest Admn., 1915/16). Kartar Singh (1934) has observed that over-protection of the *deodar* forests has resulted in a heavy under-growth and the accumulation of deep humus, so inhibiting natural regeneration; grazing is suggested in the forests of the *deodar* Working Circle in the Dalhousie Range forests of Chamba State.

Gresswell (1926/27) has noted that moderate grazing is likely to prove beneficial in coniferous forests where weed growth is excessive. The regeneration of *kail* (*Pinus excelsa*) in burnt areas in the lower Bashahr Division of Himachal Pradesh has been greatly assisted by light grazing (Punjab Forest Admn., 1927/28). In the Yeotmal Division of Madhya Pradesh grazing is reported to have played a great part in revegetation of blanks in the poor quality teak forests, by removing the heavy grass cover and encouraging reproduction of teak (Madhya Pradesh, Yeotmal Division, 1938/39). Aggarwal (1949/50) has observed that grazing does more good than harm in areas subject to heavy weed growth, but the effect may vary according to aspect, as in the Kulu forests; on the south and southwest aspects, grazing effectively prevents regeneration of *deodar*, while on the north to northeast aspect it considerably encourages it.

Grazing, however, does in most cases cause serious damage in forests, and of course, always when uncontrolled. In the special circumstances enumerated above, grazing tends to make excessively moist areas drier, reduces the fire risk in areas carrying a rank growth of grass, and prepares the way for certain non-hygrophilous plants of economic importance. In localities already none too moist, grazing compacts the soil, reduces aeration, upsets the soil-water regime, increases run-off

and the risk of erosion, and throws the succession back through stages of regressive deterioration. Woody growth is replaced by more and more inflammable grass and the stage is set for the entry of fire. Forest fires are largely associated with grazing; the rank grasses have to be burnt so that the new tender shoots may provide some grazing.

With progressive depletion of palatable grass and other species, non-palatable species resistant to grazing arise, e.g. species repelling grazing by the presence of tannins as in *teak*, acrid juices as in *Rhus*, *Aegle* and members of the Apocynaceae, thorns as in *Randia* and *Acacia* species, and sour smell as in *Holarrhena* and *Holoptelia* (Champion and Griffith, 1948). The forest is reduced to the open thorn-scrub type and erosion begins. A combination of too many goats, sheep, camels and cattle may easily and rapidly convert a forest into a desert (Bor, 1942).

Burning for Improvement of Grazing

Protection against fire has, like closure, the effect of re-establishing secondary succession in an area which has already suffered retrogression. In areas badly denuded by the combined action of fire and grazing, protection against burning has without doubt an immediate effect of permitting the return of the palatable species of grass; eventually, however, in a woodland climax, grasses are bound to be suppressed unless burning and/or grazing are employed to maintain the grassland stage.

Although intentional burning is a widespread indigenous practice in many parts of India, little exact work has been done to test the effects of annual or periodic burning or of protection against fire on the natural grasslands. The evidence at the moment is mostly circumstantial.

Rotational burning as a measure for grassland improvement was probably first recommended for forests in India by Ranganathan (1935 and 1941). In the Working Plan for the North Salem Division, a scheme of annual burning was re-commended in association with rotational grazing; the burning was to be done in patches where the grass stems were tall and tough. In the Nilgiri Plan, burning was recommended on a two-year rotation. Krishnaswamy, M.H. (1940) prescribed a similar regime of burning to be completed by March on a two-year rotation for Kurnool East, with the following objectives: (a) production of fresh succulent grass immediately after a shower of summer rain, (b) destruction of old grass culms,

(c) eradication of fungi, bacteria and insects which collect on old grass and may be harmful to cattle, and (d) maintenance of the optimal grass/tree ratio. The annual burning practised by the people under a special concession granted by Government in the Ampthill Downs of Kadaikanal is obviously what maintains a pasture type of vegetation. The Working Plan for the Yeotmal Division of Madhya Pradesh has prescribed departmental burning to improve the grass wherever necessary (Madhya Pradesh, Yeotmal Division, 1938).

There is one aspect of grass physiology which should be considered here. The annual seasonal post-monsoon growth does, if left undisturbed, ensure that ample root reserves are accumulated to provide for vigorous new growth when the next monsoon occurs. Burning causes an unnatural revival of growth which draws on these root reserves; the roots are not replenished if the young shoots are removed by the grazing animal. This annual burning followed by intensive grazing will lead to a weakening of the grass plants, and a progressive reduction in their vigour and competitive power. The palatable species are thus liable to be superseded by less palatable tougher species which do not suffer so much under this treatment.

Grass cutting in forests

Grass cutting is not generally considered to be harmful to forests. In regeneration areas, young tree seedlings also get cut with the grass, but on the whole regeneration is not materially affected; removal of the seedlings with the grass is usually inadvertent and there is still enough regeneration to fill the area. The Forest Departments have long recommended that cutting should replace grazing in order to relieve the forests of a most injurious burden; this was also a recommendation of the Royal Commission on Agriculture (Government of India, 1928). Subsequently a concerted effort was made in all States to popularize grass cutting, and in most cases it was permitted free. While this certainly increased the cutting of grass in forests, it did not reduce grazing incidence to the same extent. Except in years of fodder shortage, the concession was mostly used for obtaining grass for thatching.

Grass cutting for fodder is related to the wider question of improving livestock. Even partial stall-feeding is worthwhile only for selected animals, and quite unjustified for large herds of famished scrub cattle. Until improvements in the quality of livestock are possible, it will not be feasible to replace grazing by cutting.

Penning cattle in interior forests

In many districts of Madras where there is a heavy demand for forest grazing, the penning of cattle in the interior forests is a commendable practice. These pens or *pentas* serve to distribute grazing which would otherwise be normally confined to peripheral strips. In the capacity of Special Grazing Officer, Wilson (1951—see also Krishnaswamy, V.S. and Venkataramana Reddy, 1953) suggested the extension of this system and the formation of rotational penning units. The limiting factors to such an extension are: (a) inadequate water resources, (b) unhealthiness of interior forest areas, and (c) the absence of good roads to permit easy and rapid movement of cattle. To overcome these difficulties, Krishnaswamy, V.S. and Venkataramana Reddy (1953) have suggested the sinking of bore-wells, anti-malarial operations, and the construction of access roads.

Such pens could also be used for old and decrepit cattle and cattle from famine areas. In States like Madras, where the problem is not one of excessive grazing incidence but of maldistribution, a network of pens would correct the position, and would permit the use of grazing resources at present going to waste.

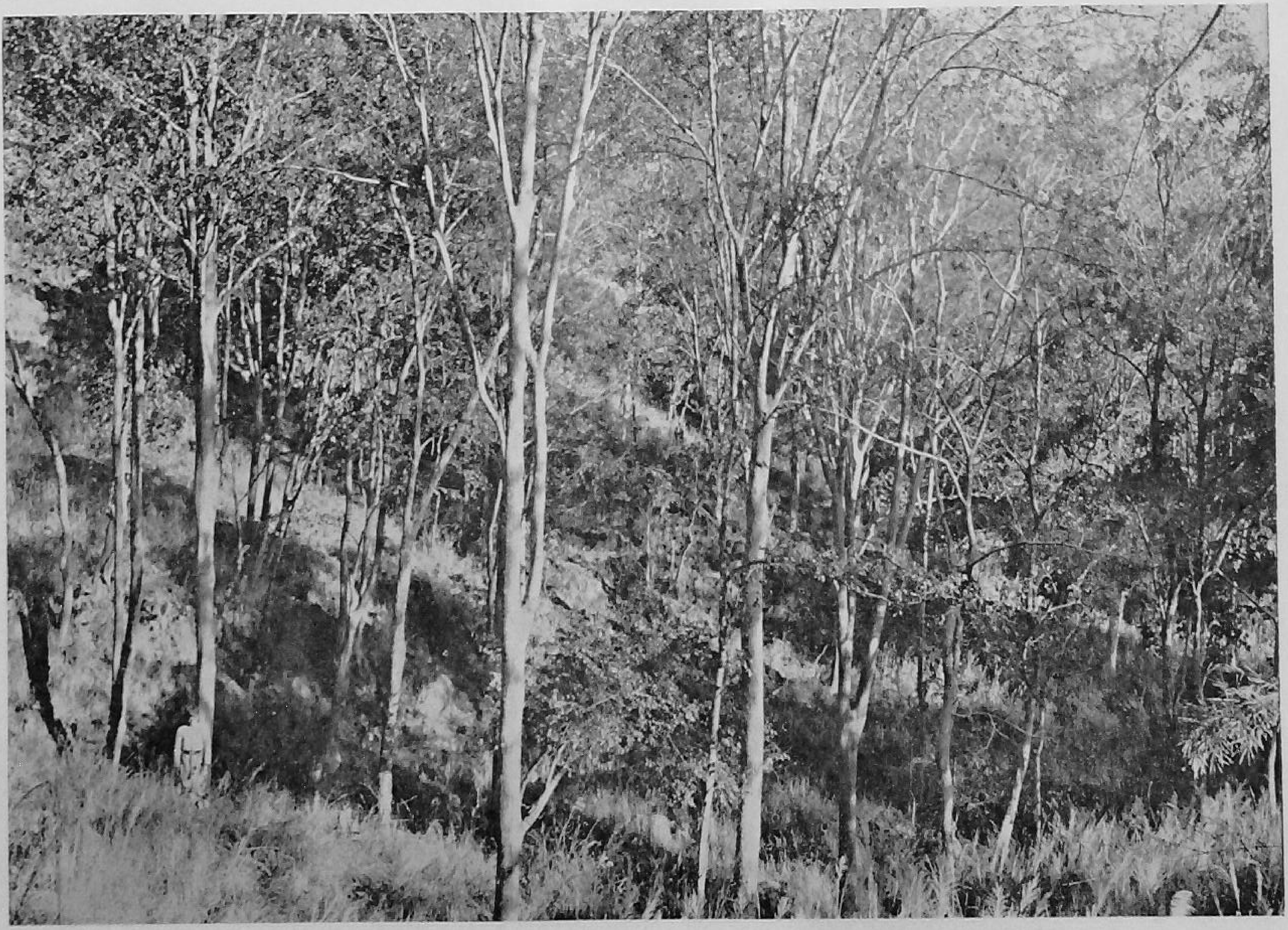
Similar cattle camps (*daihan*) inside forests are common in parts of Madhya Pradesh, the Terai area of Uttar Pradesh and in Saurashtra (*nais*). In Madhya Pradesh, cattle resorting to these camps are known as *daihan* or *gowadi* cattle. They generally come from distant villages and belong to well-to-do *malguzars* and tenants or to professional cattle breeders. The Divisional Forest Officer is empowered to move the site of cattle camps after giving due warning (see Working Plan for North Raipur by D R. Dutta, and for North Raipur sub-Division, Bilaspur Division, by G.S. Lamba).

It has been the practice for many years in the Darjeeling and Kurseong Divisions of West Bengal to build cattle sheds (*bathan*) within the forests, with the object of utilizing the fodder for stall-feeding in areas where grazing is out of the question.

Seeding experiments

Probably the most successful reseeding work in India is that carried out by the breeder of the famous Kangayam breed, the Pattagar of Palayakottai, in Coimbatore district of Madras State. *Cenchrus ciliaris*, known in Western India as *anjan* and in this locality as *kolukattai* grass, has been in cultivation on grey loamy, lime-rich soils from time immemorial. In North Coimbatore Forest

PLATE XXX



Forest of *Anogeissus latifolia* on south-west aspect on disintegrated sandstone.—Ramnagar Division, Uttar Pradesh

Photo : A. E. Osmaston

Division of Madras State, the same grass was sown in the Shanar fuel series, in one acre after ploughing and in another after harrowing. In both cases the stocking was inadequate (see Inspection Note of October 13, 1931 by Conservator K.R. Venkatarama Iyer).

Further attempts appear to have been more successful, and the Special Grazing Officer recommended the introduction of this species and also *Heteropogon contortus*, *Sehima nervosum* and *Iseilema laxum* in areas regenerated by agri-forestry. *Cenchrus ciliaris* was established successfully either under agri-forestry in combination with field crops, or by sowing broadcast after ploughing ; the latter method was considered to be too expensive. Other results were : (a) complete failure of *Iseilema laxum*, *I. anthephoroides* and *Chionachne koenigii*, (b) fair success with *Sehima nervosum*, *Andropogon pumilus* and *A. foveolatus*, and (c) complete success with *Cenchrus setigerus* (Wilson, 1951).

The Annual Report of Silvicultural Research in Madras for 1940-41 refers to the successful establishment of *Cenchrus ciliaris* by broadcast sowing in the Chandragiri Range of Chittoor Division. In Guntur Division, *C. ciliaris* and *Sehima nervosum* were successfully grown in plots in two ranges. Wilson (1951) concludes that a mere ploughing in degraded pastures, preferably on the contour, creates a good germinating bed for the seeds of natural grasses ; if done during the pre-monsoon showers, there is an immediate increase in yield of three to four times the original. With closure during the subsequent monsoon, the improvement is considerable ; the area can be grazed on the deferred system in the first year and rotationally in subsequent years. As regards legumes, both *Alysicarpus rugosus* and *Rhyncosia minima* were successful, but neither proved to be particularly palatable to cattle.

Krishnaswamy, M.H. (1940) prescribed a system of *taungya* cultivation for Kurnool East Division ; after introducing fodder and manure leaf species initially, the area is ploughed when the cultivator vacates it and the following grass species are then sown broadcast : *Sehima nervosum*, *Panicum trypheron*, *Chrysopogon montanus*, *Cynodon dactylon*, *Iseilema laxum* and *Cenchrus ciliaris*. Krishnaswamy, V.S. and Venkataramana Reddy (1953) recommend that, when Forest Working Plans are prepared, areas suitable for improvement by ploughing and sowing with grass seeds should be selected and provision made for increasing their pasture value, with a view to introducing proper grazing control.

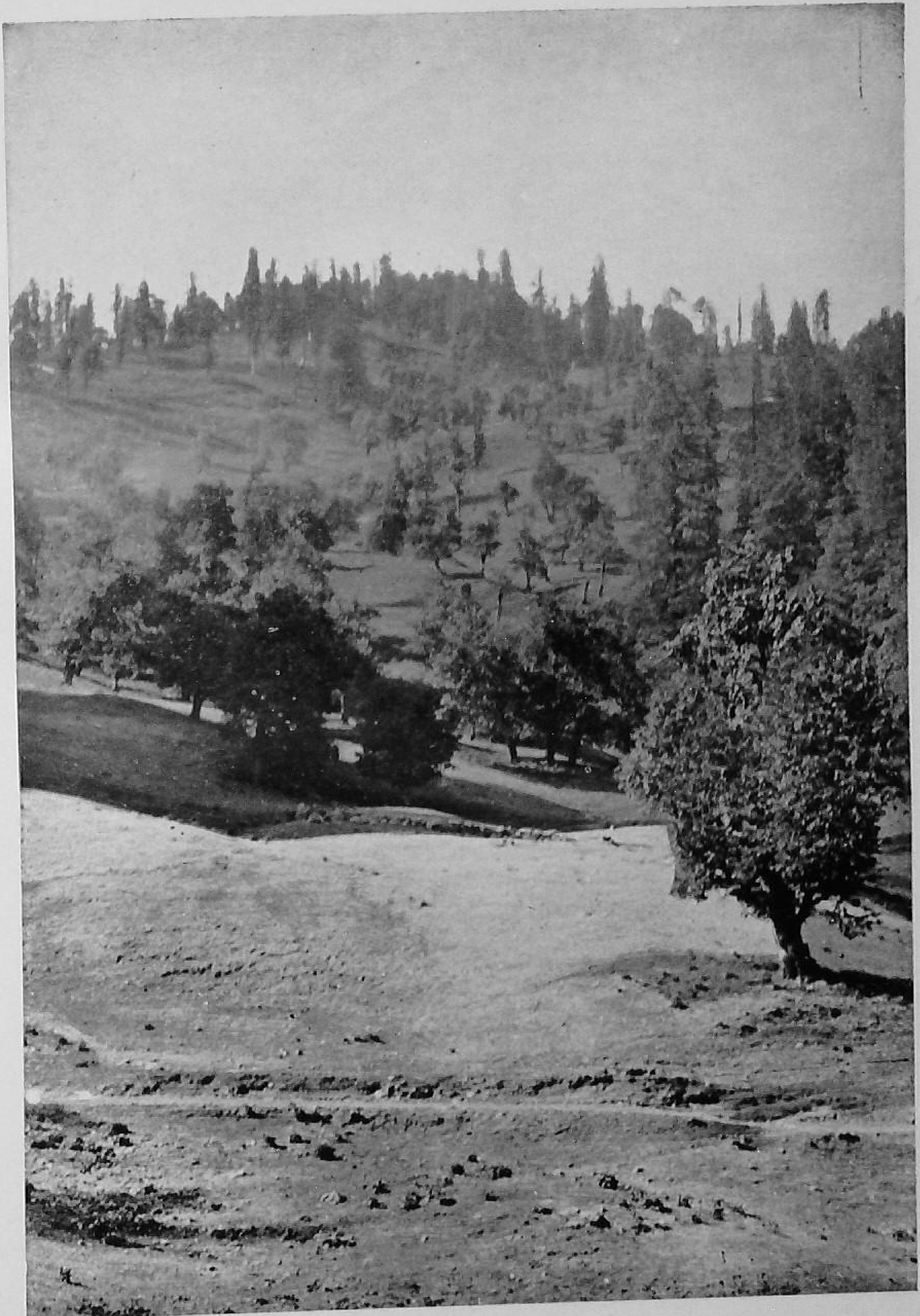
Pennisetum clandestinum (Kikuyu grass from Kenya) was tried in North Coimbatore Division of Madras, but failed in competition with indigenous grasses; it was, however, introduced successfully in the Nilgiris between 6,000 and 7,000 feet. It is also reported to have been grown successfully in Upper Shillong Farm in Assam.

Experiments in Madhya Pradesh showed that the yield and quality of certain grassland areas may be improved by systematic seeding and subsequent management (Nair and Sagreiya, 1944). Pasture Working Circles constituted under Working Plans recently revised or under revision generally contain the prescription for artificial restocking of pastures by superior grass (Lakhpat Rai, 1951).

In Hyderabad, grasses and shrubs of little fodder value have been cut, dumped in heaps and burnt, the areas ploughed or harrowed, and seeds of good fodder grasses broadcast just before the monsoon. Unnecessary trees are cut down. One simple coppice area of 30 acres near Hyderabad converted into a rumna or grassland in this way is reported to have yielded an annual revenue of Rs. 700/- to 800/- as compared with Rs. 100/- when used as a fuel coupe only.

At Nurpur (Punjab), two new species, *Apluda aristata* and *Cenchrus ciliaris*, were introduced in a plot containing *Chrysopogon montanus*, *Cynodon dactylon*, *Dichanthium annulatum*, *Heteropogon contortus* and *Sorghum halepense*. *Cenchrus ciliaris* and *Cynodon dactylon* were eliminated, *Sorghum halepense* remained only as a casual survivor, and *Bothriochloa pertusa*, *Heteropogon contortus*, *Chrysopogon montanus* and *Apluda aristata* became established as the dominant species. This was taken to indicate the need to understand the ecological status of the species one intends to introduce.

Indigenous and exotic grasses have been tested in Uttar Pradesh, under nursery and forest conditions at Clutterbuckganj, and under forest conditions in the Saharanpur Forest Division (Seth, 1952). Among exotics, *Panicum maximum*, *Digitaria seriata* and *D. swazilandensis* gave the best results if cropped regularly, and if competition from indigenous grasses such as *Saccharum spontaneum*, *S. bengalense* and *Imperata cylindrica* is prevented. The yield from the better indigenous grasses such as *Bothriochloa intermedia*, *B. pertusa*, *Dichanthium annulatum*, *Heteropogon contortus* and *Chrysopogon montanus* is, however, considerably higher than from the exotic species; they are better able to persist between lines of trees in *taungya* plantations, provided the trees have light crowns and



Mundali thatch—Chakrata Division, Uttar Pradesh

Photo : H. G. Champion

are in widely spaced lines. *Panicum maximum* and *Bothriochloa intermedia* are the most promising exotic and indigenous grasses respectively (see Table XXVIII).

It must, however, be concluded that the odds are usually decisively against exotic species, fast-growing and high-yielding though they may be, in their fight against the many indigenous species and the forces of progressive succession. Unless they are actively helped in the struggle, they cannot survive (Bor, 1942). Growing the desired grasses, whether exotic or indigenous, in forest areas is likely to involve as much preliminary clearing of the land, cultivation, care and protection as is required by field crops. It is, therefore, prohibitive as regards costs. The method does however, promise to be a practicable proposition if suitably combined with the agri-cum-silvicultural methods, e.g. the *taungya* system, which is becoming increasingly common in Indian forestry.

CHAPTER XII

THE REGULATION OF FOREST GRAZING

NATIONAL FOREST POLICY ON GRAZING

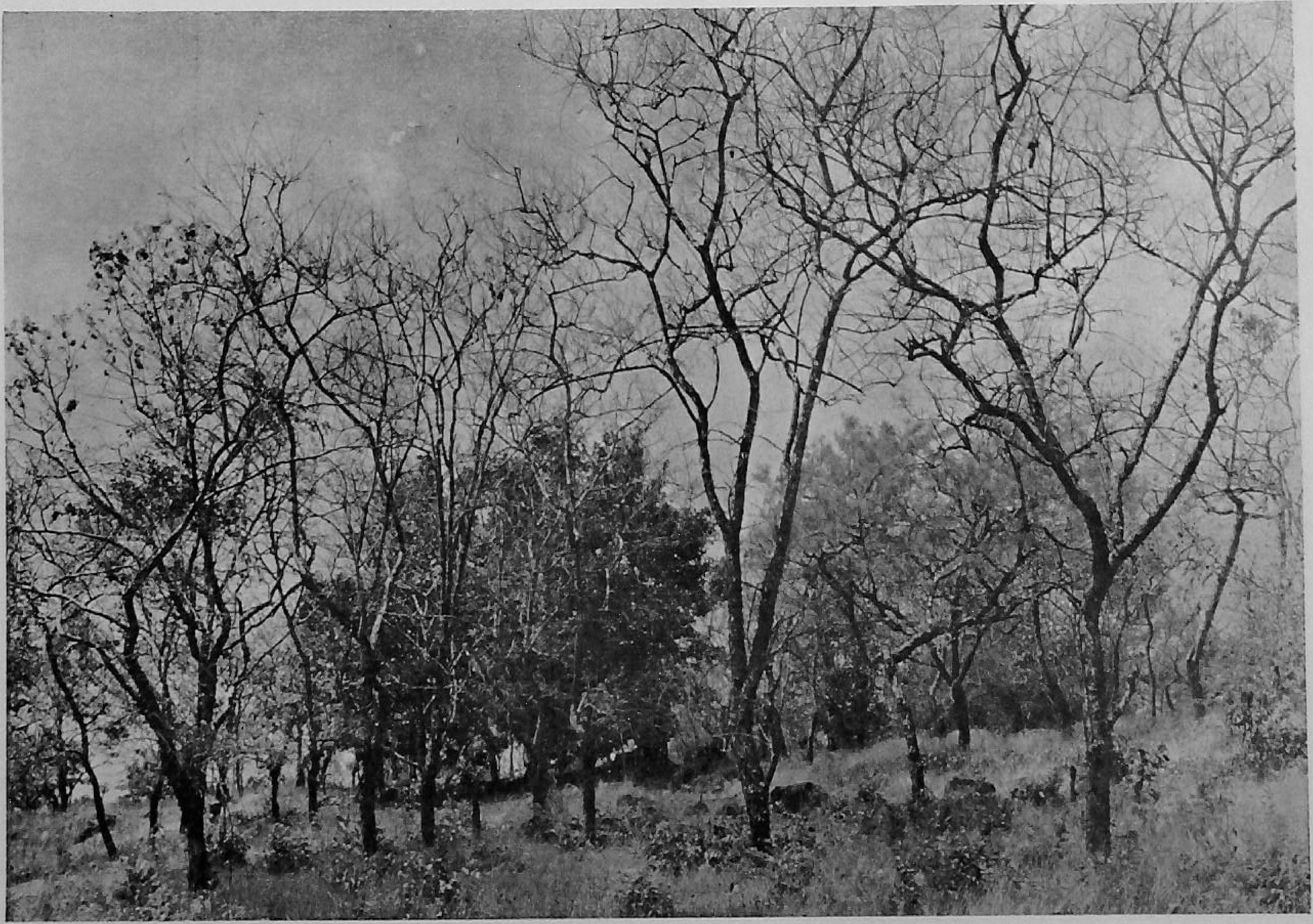
THE forest policy laid down by the Government of India in 1894, and followed until recently, prescribed that forests classified as minor forests should be managed for "the supply of fuel and fodder to the greatest advantage and convenience of the people. In doing so, due regard must be had to their habits and wishes. It may be that strict preservation and periodical closures, or the total prohibition of grazing, will result in the largest yield both of fuel and fodder in the form of hay. But that is of small avail if the people will not utilise the increased supply in the form in which it is offered to them. The customs of generations alter slowly in India; though much may and should be done to lead the people to their own profit, yet it must be done gently and gradually...always remembering that their contentment is no less important an object than their material advantage."

Although it might presumably have been a simple matter for an authoritarian government to lay down a firm policy and to implement it with vigour, emphasis was nevertheless placed on the contentment of the people rather than on their material advantage. Forest officers knew quite well what should be done, but were powerless to do it. As a result, forests were overgrazed and ravaged by hordes of semi-starved cattle. The present administration has inherited this situation and necessarily had to bear it in mind in framing the new forest policy from 1952. It will be years or decades until it is possible to persuade the people to accept any material change in the existing grazing practice.

The new policy statement known as the "National Forest Policy in India" was made by the Government of India in 1952. Among the four vital national needs which form the fundamental basis for this policy is 'the need for ensuring sustained supplies of grazing'. Paragraphs 21 and 22 discuss the implications of grazing in forests and the future policy which is to be adopted.

"21. *Grazing.* The controversial question of grazing in State forests calls for a clear definition of policy. Speaking generally, all grazing in

PLATE XXXII



Acacia sundra on shallow, red soils but under a good rainfall, with grass species and *Gardenia gummifera*.—North Mangalore Division, Madras

Photo : H. G. Champion

forests, particularly unlimited or uncontrolled grazing, is incompatible with scientific forestry. At the same time, grazing does take place in forests and must be accepted as a hard fact. There are indeed circumstances in many regions where a moderate amount of grazing does little direct harm, and may even do a great deal of indirect good in reducing the risk of fire and in suspending regression at a desirable stage. But efficient forest management requires that grazing should be regulated as regards the time and place, as also the number of cattle admitted. The formulation of the grazing policy should be based on the following cardinal principles:

"(a) Continuous grazing on the same areas by large herds is destructive of the better strains of grasses and leads to a deterioration of the grass complex. Wherever it is permitted and is in great demand, efforts should be made to introduce rotational grazing, the benefits of which should be explained and demonstrated to the villagers.

"(b) Cheap forest grazing has a demoralising effect and leads to the vicious spiral of reckless increase in the number of cattle, inadequat forest grazing, reduced quality of herds and further increase in the numbers to offset the fall in quality. Free and indiscriminate forest grazing is, therefore, a serious disservice to cattle breeding. The notion that a farmer's wealth must be reckoned in terms of the number of cattle he owns, regardless of quality, is one of the causes of India's uneconomic cattle wealth and must be combated.

"(c) Grazing should not be looked upon primarily as a source of revenue. But the simple and obvious way of regulating and controlling grazing as also improving the quality of both grazing and cattle themselves, is to institute a reasonable fee for the privilege of grazing.

"(d) Grazing must not be allowed in regeneration areas and young plantations during such periods as the seedlings require for establishment; otherwise they stand in danger of being browsed or trampled upon.

"(e) Grazing incidence should be kept at a minimum in 'Protection Forests'.

"22, *Sheep and goats.* Experience gained in India and elsewhere points to the imposition of restrictions on sheep grazing in forests, and the

total exclusion of goats therefrom. The damage to young plants caused by the browsing of these animals is often irreparable, and their admission into the forest is incompatible with the aims and objects of forest management. The creation of special fodder reserves under strict rotational control is indicated for the purpose."

Although no exception can be taken to the fundamental principles enunciated here, the line of action proposed is not likely to be effective, or to yield quick results. After saying that "efficient forest management requires that grazing should be regulated as regards the time and place, as also the number of cattle admitted", it seeks to restrict the number of cattle, not in a direct way, but indirectly by reducing the extent of cheap and free grazing and imposing a reasonable fee. As far as the regulation of grazing in time and place is concerned, the policy merely suggests that efforts should be made to introduce rotational grazing, by explaining and demonstrating its benefits to the villagers. One may, therefore, ask when the basic principles so ably presented are to be implemented. Those who were responsible for framing the policy were quite aware of the inadequacy of the action proposed, but were, at the same time, faced with the realities of a difficult situation. There is no apparent alternative. The people, the masters of the situation, must be educated slowly, and we must wait until they permit the authorities to carry out measures which they know are correct. Until then, politicians and legislators cannot be expected to support unpopular actions such as increasing grazing fees, annulling absurd grazing rights, and regulating grazing on a rotational or other controlled basis. On the constitutional side, the autonomy of States in forest matters is apt to militate against effective and uniform adoption of the grazing policy throughout the country. From this point of view also, it will be necessary to wait until the people all over the country realise the paramount national interests involved in accepting and pursuing a correct grazing policy.

Grazing and Indian Forest Laws

The Indian Forest Act covers the States of Bombay, West Bengal, Uttar Pradesh, Bihar, Punjab, Madhya Pradesh and Orissa, and may be extended to any other Part 'A' or Part 'C' State. Some of the Part 'C' States have already applied the provisions of the Indian Forest Act to their areas. Two Part 'A' States, Madras and Assam, have their own forest laws, namely, the Madras Forest Act of 1882 and the Assam Forest Regulation of 1891. Some Part 'B' and Part

Plate XXXIII

Nilgiri sholas and grassland, the shola belt limited to the hollows, especially at the heads of the water courses.—Ootacamund, Madras

Photo : H. G. Champion

'C' States also have their own forest laws ; more backward States, which were formerly the Indian states ruled by princes, have no comprehensive forest laws, but this deficiency will presumably be made good.

This discussion will be confined to the Indian Forest Act which applies to the largest area in the Indian Union; most of the important forest laws in the country were modelled on this Act. The Act classifies forest areas belonging to the Government into (a) reserved forests, (b) village forests, and (c) protected forests. Village forests are also reserved forests except that they are assigned to village communities.

In constituting reserved forests, grazing rights are excluded as far as possible. Where this is not possible, such rights may be exercised subject to specific regulations regarding number and description of cattle, seasons of grazing, areas to be grazed, etc. Where the continuance of grazing rights in a reserved forest prejudices the maintenance of the forest itself and thereby the continued exercise of these rights, the Act provides for commuting the rights either by cash payment or by grant of land or in any suitable manner. Thanks to these legal provisions, reserved forests are largely free from grazing rights ; even where grazing rights exist, their exercise is generally subject to salutary regulation.

The settlement of rights in protected forests, on the other hand, is imperfectly organized. There is no bar to subsequent accrual of rights, and these forests, therefore, become burdened with rights. The Act, nevertheless, has some provisions calculated to avert the situation which the exercise of these rights should create.

The State Governments may close any portions of such forests for periods not exceeding 30 years, provided these enclosed portions are sufficient to meet the needs of right holders and are reasonably convenient in location. This power of closure may be effectively used to rest and improve overgrazed and deteriorated forest pastures. State Governments may also regulate pasturing of cattle in the protected forests. Unlike the reserved forests, the nature of the regulation is not specified but its scope is ample in terms of general principles of law. All details of how, when and where the grazing rights are to be exercised to prevent deterioration of the forests (the servient estate) without curtailing the rights (the dominant estate) will constitute regulation of grazing. In fact, in the general nature of all easements, grazing rights cannot be unlimited and can be curtailed. One obviously cannot have the right to graze so many cattle in a forest that it turns into a

desert. These rights are often of the nature of prescriptive rights, i.e. they have long existed openly and peacefully, but without any original grant which can be traced; as such their extent and quantity are liable to be determined under express legal provisions. Such rights are perpetual, implying that the servient estate, namely, the forest, must be maintained and all destructive acts avoided. It would, therefore, be possible to curtail rights to the extent that the servient estate cannot carry them in perpetuity, but such curtailment would have to be compensated (Baden-Powell, 1893). Legally, therefore, there is scope for adequate regulation of grazing rights even in protected forests.

The Forest Act thus contains provisions for regulating grazing rights in reserved and protected forests, the extent of the regulation being specified in the former case and implied in the latter. Rights to cut grass or lop trees for fodder are similarly defined and regulated under the Act, but these rights are rare in reserved forests. The Act also vests powers in the States to regulate pasturing of cattle even in private forests in the interests of soil and water conservation, public health, and protection against certain dangers and calamities.

We shall now review the scope of the provisions to regulate grazing rights in reserved forests only, since these constitute the major permanent national forest estate. Under sections 14, 15 and 16 of the Act, grazing rights are admitted and allowed to continue in reserved forests with due regard to the maintenance of the forest itself and the continued exercise of rights, and are subject to regulation as regards (i) number of cattle, (ii) description of cattle, (iii) seasons of grazing, (iv) areas of grazing, and (v) other considerations as may be required under rules made by the State Governments.

Number of cattle: This will be fixed with reference to the actual requirements of the right holders and the carrying capacity of the forest. The nature of the need is to be considered; for example, cattle for commercial purposes, and not for ploughing or household needs, are not generally allowed to graze (Jagdamba Prasad, 1950). Large herds of cattle maintained by an agriculturist for the production of *ghee* for sale cannot be considered to be his need as an agriculturist. A distinction can, therefore, be made between essential and non-essential cattle, and the latter may be excluded from the forests; the usual method in India is to count the houses, the number of ploughs, etc. in a village and estimate the cattle needed for cultivating, breeding and milk plus a reasonable expansion. Even recognising this need, the number actually admitted will be subject to the over-riding

Plate XXXIV

Anamalai grass hills, Madras

Photo : J. M. Sweet

consideration that the forest must be maintained. The question of excluding surplus cattle may arise, but compensation in that case will be necessary if a right to graze exists.

Description of cattle : The Indian Forest Act defines cattle as including elephants, camels, buffaloes, horses, mares, geldings, ponies, colts, fillies, mules, asses, pigs, rams, ewes, sheep and lambs, goats and kids. Pigs are seldom grazed in forests. The only animals actually grazed are cows and bullocks, buffaloes, sheep, goats, camels and elephants (only locally important) and equines (very rarely, except in the high pasture lands of the Himalaya).

Although the Act does not make it possible to exclude undesirable types of animals, this would be possible under section 16. A distinction would have to be made between the grazing animals and the browsing animals, the latter being elephants, camels, goats and sheep.

Camels are confined to those parts of India which carry a desert or shrubby type of growth. Even such forests are important for fuel ; no forest can survive camel grazing for long, still less the dry fuel forests, and camels should, therefore, be excluded from them. Goat grazing is inconsistent with the maintenance of any forest cover and should, therefore, be prohibited. Sheep are less undesirable than goats ; they begin to browse when there is not enough palatable grass available and should, in such circumstances, be prohibited. Buffaloes do not generally browse, but they are very dangerous on steep slopes where their heavy tread dislodges the soil and exposes the roots of trees.

In all those cases where grazing has to be completely, or almost completely, prevented, action is possible under the provisions of section 16 of the Indian Forest Act which gives authority to commute rights inconsistent with the maintenance of the forest.

Seasons of grazing : Forests require protection in particular seasons, e g. the fire season. Grazing may also have to be reduced during early spring until herbage becomes established. This provision makes it possible to implement deferred and rotational grazing.

Portions of forests in which grazing is to be allowed : This is another salutary provision which makes it possible to close certain areas to grazing permanently or at intervals. A prescription that grazing should be carried on only in areas

declared open for the purpose from time to time will cover the needs of both short and long-term closures.

Other considerations which may be required under rules made by the State Government : This is a general provision which facilitates other regulatory measures, such as insistence on grazing tickets, cattle bells, the presence of responsible herdsmen, etc. and restrictions about lighting fires, constructing sheds, enclosures, etc.

Punitive closure : This important provision under sections 26 and 33 of the Act covers fire caused wilfully or by gross neglect in a reserved or protected forest. The State Government may, in addition to any penalty which may be levied under the Act, suspend the exercise of any right to pasture or to forest produce in the forest for such a period as may be deemed fit. A closure of this type has both a corrective and a silvicultural objective, and may also be highly desirable for correct grazing management.

It is obvious that the Indian Forest Act contains practically all the legal provisions needed for effective regulation of grazing in reserved forests. The position is not so clear in protected forests where difficulties may arise in practice, but there is nothing to prevent their constitution as reserved forests at any time when the situation demands it. It is necessary to extend the provisions of the Act, with any minor modifications which local conditions may require, to the few States which do not have their own forest law. Once this is done, the full implementation of the national forest grazing policy will be hampered not for want of an adequate forest law, but for other reasons, political and social.

Forest laws and forest grazing in practice

An idea of the areas to which the above regulatory provisions apply is given by the following statement of the total forest areas under the control of Forest Departments (Government of India, 1952).

Type of forest	Sq. miles
Reserved	99,476
Protected	14,513
Unclassed	24,162

Reserved forests where maximum control of grazing is possible represent 72 per cent of the total forest area. This may be regarded as generally satisfactory, but there are a few States where the position is otherwise (Government of India, 1952).

TABLE LXX

Forest area in different States

State	Total forest area (sq. miles)	Percentage of component classes		
		Reserved forests	Protected forests	Unclassed forests
Assam	20,948	31.4	0.4	68.4
Bihar	2,381	57.3	37.0	5.7
Orissa	2,874	48.6	51.4	...
Punjab	3,878	12.5	80.9	6.6
Hyderabad	9,466	50.6	43.1	6.3
PEPSU	238	25.2	16.4	58.4
Bilaspur	200	Negligible	24.0	76.0
Himachal Pradesh	2,862	22.2	24.6	53.2
Tripura	3,610	28.3	...	71.7
Vindhya Pradesh	8,000	44.3	13.3	42.4

The Punjab has 80.9 per cent under protected forest with all that this implies, namely, existence of excessive rights and difficulties in controlling grazing, lopping, etc. Orissa, Hyderabad and Bihar have considerable areas of protected forests. In the Punjab, rules under section 76 of the Indian Forest Act have been framed in the case of certain forests which come within the purview of this section and are known as 'unclassed forests'. Some degree of protection is, therefore, ensured in these forests under the Indian Forest Act (Mohan, 1954). Other unclassed forests to which the Indian Forest Act does not apply represent a very large part of the forest area in Bilaspur, Tripura and Assam, and a lesser part in PEPSU, Himachal Pradesh and Vindhya Pradesh. The fact that the

provisions of the Indian Forest Act have not been enforced in these areas may have been due to their remoteness and consequent relative freedom from abuse. All such areas should now be constituted into reserved or protected forests if they are to be maintained permanently as forests ; at the moment closure or any form of effective grazing management is quite impossible.

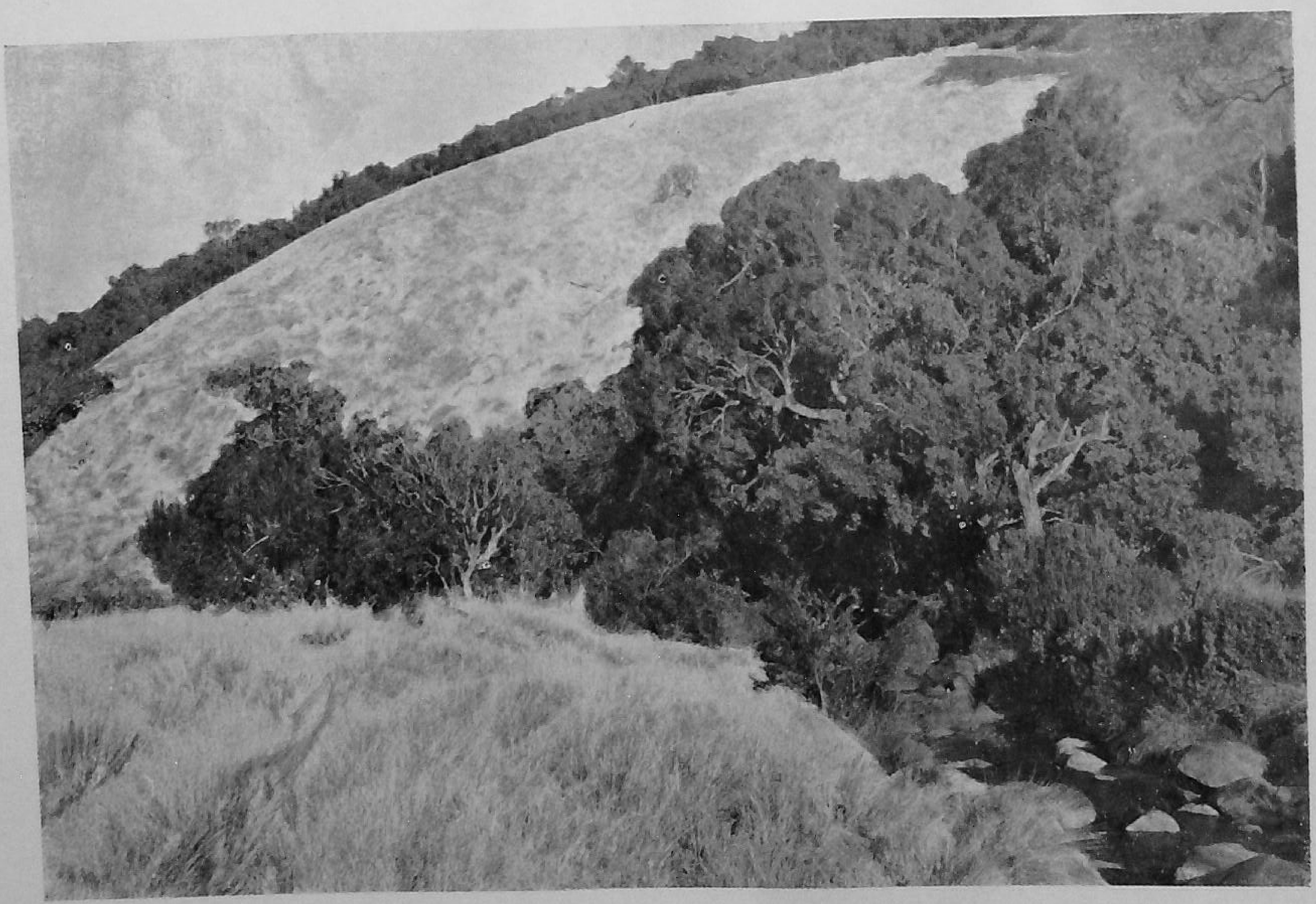
When one considers the number of animals grazing in the forests by right, it does not generally appear that excessive numbers have been admitted at settlement. Two glaring exceptions are the Punjab and Himachal Pradesh. The Forest Administration Report for the Punjab for 1950-51 shows that 1,900,289 animals grazed by right under settlement in 4,292 sq. miles of forest open to grazing or 1.4 acres per animal. The corresponding figure for Himachal Pradesh in 1947-48 was 2.5 acres per animal (Government of India, 1952). The figure for Bihar is 4.2 acres, for Uttar Pradesh 5.2 acres. One cannot avoid the inference that the Punjab and Himachal Pradesh settlements were too much in favour of right holders and too little in the interests of forests themselves. It is inevitable that the forests will be denuded and the exercise of the grazing right will itself ultimately become impossible. West Bengal, Hyderabad, Saurashtra and Bhopal do not appear to have admitted any rights to forest grazing. Assam, Bombay, Madhya Pradesh and Travancore-Cochin have also been extremely strict (Government of India, 1952).

The extent to which browsing livestock have been permitted to graze in the forests should be taken as an indication of how far forest settlement in the various States has ignored the basic requirements of law regarding such rights. We have already seen that the grazing of camels and goats is incompatible with good forestry. Grazing of goats, sheep and camels was admitted at settlement in a number of States. See Table LXXI.

As a single figure is given for sheep and goats, it is not possible to state the number of goats concerned. Sheep browse only in exceptional circumstances and are, therefore, much less dangerous than goats ; even States which exclude goats from their forests, such as Madras, permit sheep grazing.

In general, it appears that the settlement of grazing rights has been fairly strict, but that it has been lax as regards total number of animals admitted in the Punjab and Himachal Pradesh, and as regards admission of browsing animals in the Punjab and Kashmir and to a lesser extent in Bilaspur, Himachal Pradesh and Vindhya Pradesh.

PLATE XXXV



Tempepate evergreen forest along a stream, with grassland and another shola behind.—The trees are *Tupinia calophyllifolia*, *Photonia*, *Eurya jamonica* and *Euonymus arenulata*, with shrubs of *Thodomyrtus*, *Gaultheria* and *Strobilanthes* in foreground.—Avalanche Nilgiris, Madras

Photo : Forest Research Insti ute

TABLE LXXI

Number of browsers grazed free by right in different States

State	Number of browsers grazed free by right at settlement	Remarks
Assam	45	
Bihar	78,978	
Madras	3,127	
Orissa	120	
Punjab	741,562	Figures relate to 1950-51. Only 9,697 of these animals relate to reserved forests and the rest to protected and unclassed forests
Jammu and Kashmir	290,840	
Mysore	9,777	
Bilaspur	41,364	
Himachal Pradesh	65,415	
Vindhya Pradesh	53,000	

The figures relate to 1947-48 (Government of India, 1952), except for the Punjab (Punjab, 1950-51).

But the initial settlement of rights is not everything. Standards observed at settlement have been mentioned merely to indicate that only in a few exceptional cases has the observation been lax from the start. Whether forest grazing has or has not been admitted as a right, it has nevertheless been permitted as a privilege. The existence of a comprehensive forest law like the Indian Forest Act or the Madras Forest Act, and its strict enforcement both in letter and spirit while settling grazing and other rights and constituting the forests, could not save them from excessive grazing. The demand from the local public has resulted in the grant of grazing concessions on a scale sufficient to nullify the effect of any restrictions enforced at settlement. Overgrazing is, therefore, as obvious in forests free of grazing rights as in those burdened with them, and the vast majority of animals grazing in forests do so without any right thereto. In 1947-48 (Government

of India, 1952), while some 7,000,000 animals grazed in forests by right under settlement, 17,700,000 did so without rights ; of the latter, 4,600,000 were grazed free 5,300,000 at privileged rates and the remainder on payment of grazing fees at full rates.

The grazing incidence in the various States has already been shown in Table LXIX ; that statement showed that West Bengal, Hyderabad, Saurashtra and Bhopal, which had not admitted any grazing rights at settlement, and Assam, Bombay, Madhya Pradesh, Madras, Travancore-Cochin and Ajmer which have been quite strict in admitting such rights, recorded the grazing incidence in 1947-48 as shown in Table LXXII.

TABLE LXXII

Grazing incidence in States

State	Acres per animal
West Bengal	19.0
Hyderabad	3.5
Saurashtra	4.3
Bhopal	3.2
Assam	178.8
Bombay	2.9
Madhya Pradesh	3.2
Madras	4.5
Travancore-Cochin	55.4
Ajmer	1.9

Apart from West Bengal, Assam and Travancore-Cochin, the position is quite serious; if this is the case with States which had started with a will to limit grazing in forests, what of those which were unrestrained in admitting grazing rights? Punjab and Himachal Pradesh had admitted the greatest proportion of cattle at settlement and Kashmir had permitted too many browsing animals; these States recorded a grazing incidence of 0.9, 1.0 and 1.3 acres respectively per animal, the heaviest in the country. The grazing incidence in Bihar, Uttar Pradesh and Vindhya Pradesh, which had not been sufficiently strict at settlement, was 3.9, 3.1 and 4.5 acres respectively per animal.

TABLE LXXIII

Total number of livestock of various kinds grazed in forests in 1947-48

Kind of animal	Number
Buffaloes	2,838,463
Cows and bullocks	13,193,974
Goats and sheep	8,300,535
Camels	12,450
Other animals	325,638
Total	24,670,160

Browsers constitute quite a high proportion on the whole, and it is interesting to study the position State-wise.

TABLE LXXIV

Number of browsing animals (camels, goats and sheep) grazed in forests in different States

State	No. of animals
Assam	1,650
Bihar	80,208
Bombay	363,032
Madhya Pradesh	363,005
Madras	695,949 (only sheep)
Orissa	39,709
Punjab	1,645,282*
Uttar Pradesh	367,130
West Bengal	167
Hyderabad	196,176
Jammu and Kashmir	2,580,900

* Figures for 1950-51 (Punjab, 1950/51).

TABLE LXXIV—contd.

Number of browsing animals (camels, goats and sheep) grazed in forests in different States

State	No. of animals
Mysore	93,123
Saurashtra	11,041
Travancore-Cochin	8,544
Ajmer	*-nil-*
Bhopal	13,266
Bilaspur	76,491
Coorg	*-nil-*
Himachal Pradesh	1,241,000
Tripura	*-nil-*
Vindhya Pradesh	92,373

TABLE LXXV

Number of camels included in Table LXXIV

State	No. of camels
Punjab	3,664
Uttar Pradesh	1,549
Jammu and Kashmir	3,600
Saurashtra	95
Bilaspur	27
Himachal Pradesh	896
Vindhya Pradesh	2

Forests are also subject to illicit grazing, sometimes on quite a large scale. See Table LXXVI. The Punjab again takes the first place with the highest number of offences; with a forest area one-fourth that of Madhya Pradesh, it has recorded more grazing offences than that State. The data relating to Part 'B' States are obviously unreliable. If one takes the figures for Part 'A' and Part 'C' States as more representative and considers that each offence might involve several cattle and that many offences go undetected, one obtains an indication of the volume of illicit grazing.

TABLE LXXVI

Number of grazing offences—grazing without permission or in tracts in which grazing is prohibited (1947-48)

States	No. of grazing offences
Assam	54
Bihar	276
Bombay	4,580
Madhya Pradesh	7,776
Madras	3,911
Orissa	455
Punjab	7,931
Uttar Pradesh	2,082
West Bengal	687
Hyderabad	561
Jammu and Kashmir	Details not available
Mysore	136
PEPSU	70
Saurashtra	40
Travancore-Cochin	3
Ajmer	1,120
Bhopal	239
Bilaspur	302
Coorg	21
Himachal Pradesh	1,578
Kutch	Details not available
Tripura	30
Vindhya Pradesh	192
Total	32,044

In spite of having enlightened forest laws for nearly a century, the situation has improved little. It appears that cattle are never refused admission to the forests, no matter how necessary this may be. Cattle denide rights of user at settlement have nothing to lose as they still get into the forest as a matter of privilege or concession. On top of all this is the illicit grazing. It is essential that this misuse of the forest resource must stop and that forest grazing should be properly organized if the forests themselves and the grazing they provide are to be conserved.

Systems of Grazing in Forests

Forests grazing is generally organized on the basis of grazing permits, passes or licences, the price varying from place to place ; they authorise the grazing of cattle for periods from one month in Bengal and Bihar to one year in Madras and other places, in forest units varying from a forest block to a whole division. Apart from the variations indicated above in grazing fees, duration and extent and variation in the control of grazing incidence, the permit system appears to be the rule, although in Madras and Mysore other systems of grazing are in operation.

Three systems apply in the forests of Madras State. Their essential characters are as follows :

(a) *Permit system :* This is similar to the system operating in most other States. Permits are issued departmentally at rates varying from -/3/- to Re. 1/- per cow unit. A whole division constitutes the grazing unit. The permit is valid for a *fasli* year, i.e from 1st of July to 30th June. Grazing incidence may or may not be controlled.

(b) *Village system :* In a few localities, village *panchayats* are responsible for the grazing in a forest area with obligations to limit the number of livestock and to protect the area. If these obligations are fulfilled, a proportionate rebate of the grazing fees is given. There are two types of this system—the forest village system and the hill village system. These are similar except for the fact that the rebate of grazing fee may be 50 per cent in the former and 100 per cent in the latter. Efforts to extend this system elsewhere have failed as villagers do not normally like to take the responsibility for controlling grazing and protecting forests.

(c) *The* Kancha *system :* This is perhaps the best system in India. It is

in vogue in Nellore Forest Division which is noted for the excellent Ongole breed of cattle. The system is said to have originated in 1874, was abolished in 1898, but reintroduced in 1902. The grazing area is divided into convenient blocks known as *kanchas*. In 1941-42 there were 129 *kanchas* covering 126,329 acres; 25 were called foreign *kanchas*, intended for the use of foreign cattle, from villages more than five miles from the reserved forests; the remainder were local *kanchas* to meet the needs of villages within five miles of the reserved forests. The District Forest Officer may permit foreign cattle in local *kanchas* if their area is surplus to local requirements, or may convert a foreign *kancha* into a local one. Permits are issued departmentally according to estimated capacity, an average of two acres per cow or buffalo unit in certain reserves, and four acres in others. The closure of *kanchas* to grazing for three months in the year from the 1st July is the most important and salutary feature, as it helps to conserve the edible grasses (Krishnaswamy V.S. and Venkataramana Reddy, 1953). The *kancha* system is believed to have largely contributed to the preservation of the Ongole breed of cattle (Anon, 1937).

Under the permit system in Madras, it has become common practice to pen cattle covered already by permits in interior forests adjoining water sources. This penning, done under special licence in approved areas, is adopted when there is little grazing left near the villages. The practice helps to utilize unused grazing resources in the interior to relieve the grazing grounds on the periphery of villages.

The Special Grazing Officer of the Madras Government recommended in 1942 two systems of grazing known as the Local Block and the Special Block systems respectively. The first consists in making the forest block the grazing unit instead of the division as in the past, and in controlling incidence. The Special Block system is for the development of more compact blocks providing exceptionally good grazing. Both are variations of the present permit system.

Five systems are in vogue in Mysore (Kadambi, 1941, and K.A. Venkata Rao, 1941):

(1) *Grazing on pre-paid permits*: This corresponds to the permit system of Madras.

(2) Kancha *system*: This appears to have been introduced in Mysore in 1924, and resembles the Madras system. "The right of grazing is auctioned off,

the bids being per acre", instead of permits being issued departmentally as in Madras.

(3) *Forest village system* : Separate blocks of forests are allotted to different villages or groups of villages, their size depending on the number of cattle. Grazing is free or at concession rates fixed at the time of forest settlement. This appears to differ from the village system in Madras.

(4) *Lump sum grazing system* : The village is the unit and a lump sum payment is made to the Forest Department for grazing all the cattle in the village. Payment is made in three instalments, in July, August and September every year. This system appears to have been initially favoured by the ryots and was introduced throughout the State in 1927; the ryots are now reported to prefer the pre-paid permit system.

(5) *Plantations or* Kavals *system* : *Kavals* are areas of reserved land in which the right of grazing is auctioned annually with no restriction as regards number of cattle. Where grazing is considered detrimental, only grass-cutting is permitted.

Of these five systems, grazing is confined to compact blocks and the incidence limited to capacity only in the *Kancha* system. The lump sum grazing system is the next best ; it controls the number of cattle but does not restrict the grazing to specific areas. The other systems involve unrestricted grazing.

Grazing Fees

An attempt to summarize the somewhat variable situation as regards the imposition of grazing is made in Table LXXVII. Only in respect of Madras State is any historical information available. A grazing tax is believed to have been levied in Guntur District as far back as 1797, which yielded rupees one lakh in Guntur and rupees one-and-a-half lakhs in Nellore in 1856. The old *Rajahs* and *zamindars* in Kistna District were in the habit of giving grazing leases of hill and jungle areas to their favourites, who then collected maximum grazing fees ; the rate per animal in the northern *taluks* of Kistna varied from Re. 1/- to Rs. 7/8/-.

The collection of grazing tax was limited to the hills in 1856. The Government later formulated its grazing policy whereby essential cattle of the border villages were given preference in reserved forests, on a scale of fees fixed to meet the cost of control and improvement (buffaloes, five annas ; bulls, cows,

etc. three annas ; sheep and goats, one anna and six pies per year). The levy could be raised for cattle from outside districts or in areas reserved for cattle breeders. The scale was subject to periodical revision ; until 1938, the maximum was one rupee and the minimum three annas, but the first popular Government of that year reduced these rates by 50 per cent. The current rates operating in Madras are given in Table LXXVII.

Almost all States distinguish between essential cattle kept for bona-fide agricultural and domestic purposes and those kept for trade. Essential cattle are allowed free or at concession rates, the others at higher rates. In Madhya Pradesh a distinction is made even among non-essential cattle : (a) those in excess of indispensable agricultural needs, but necessary for quasi-agricultural purposes such as draught animals and animals which supply milk and manure and (b) those further in excess. These two classes are charged ordinary and commercial rates respectively, whereas essential cattle are charged privileged rates.

In no case do the grazing fees represent adequate compensation for what is taken from the forests. Forest officers have stated at successive Silvicultural Conferences and elsewhere that cheap and free grazing is responsible for over-grazing in forests, and that once forest grazing is placed on an economic basis, it will cease to be a problem. The great difference made by raising or reducing the grazing fee even slightly has been shown from experience. In Madhya Pradesh a 25 per cent reduction in grazing fees in 1938 led to an increase of 92,000 in the number of forest-going cattle, but a reduction at the same time of Rs. 80,000/- in the grazing revenue (Nair and Sagreiya, 1944). The abolition of grazing fees in Bombay in 1937 had the effect of increasing forest grazing cattle by more than 50 per cent, even though the fee was previously as low as four annas per head of horned cattle and two annas per sheep. The national forest policy has rightly emphasized the importance of a reasonable fee for the privilege of grazing as a "simple and obvious way of regulating and controlling grazing as also improving the quality both of grazing and cattle themselves".

The extent to which cattle grazing is being subsidized by Government, on account of rights and concessions, and how grazing and fodder grass nevertheless form a not inconsiderable source of revenue is shown for 1947-48 in Table LXXVIII. (Government of India, 1952).

Table LXXVII

Statement showing the grazing fees as applicable in the various States of the Indian Union

States	Cows	Bullocks	Buffaloes	Equines	Sheep	Goats	Camels	Elephants	Source and remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Assam :									
Non-notified areas	-/4-- to -/12/-	-/4/- to -/12/-	1/- to 6/-					Rs. 15/-	Government rules published under notification number 2912R of 25th September, 1934. Rates to apply only to cattle maintained for commercial purposes
Notified areas		Selected breeding free; Castrated -/4/- to ./12/- Uncastrated -/12/- to 2/4 -						Calves Rs. 7/8/-	
Bihar :									
Professional graziers, traders and contractors	-/2/-		-/4/- -/4/- per month	-/2/-	(All other	animals	-/2/-)		Bihar and Orissa Forest Manual, 1935 (Outside the protected forests, rates are revised from time to time)
Bombay:	Free for all animals								Forest Administration Report, 1950-51
Madhya Pradesh :									
Privilege rates	-/1/- to -/4/-	-/1/- to -/4/-	-/3/- to -/8/-						Central Provinces and Berar Forest Manual 1932. Reduction of 25 per cent in privilege and ordinary rates is reported in 1938
Ordinary rates	-/4/. to 1/-	-/4/- to 1.	-/8/- to 2/-	-/3/- to -/12/-	-/1/6- to -/3/-	-/2/- to -/4/-			
Commercial rates	-/8/- to 1/4/-	./8/- to 1/4/-	1/- to 3/4-	-/4/- to 1/8/-	-/2/- to -/4/-	-/3/- to -/5/-			
Madras :	-/1/- to -/12/-		-/2/- to 1/8-		-/-/6 to -/6/-	Not permitted			Reply to I. C. A. R. questionaire

Punjab Kalesar Reserve Forest Ambala Forest Division—				-/8/-					Working Plan 1949-50 to 1964-65 by S. Jaswant Singh
i) Villagers—			1/8/- to 4/8/-; Calves -/12/- to 1/8/-						
ii) Professional graziers			Rs. 10/- ; Calves 5/-						
Shahpur Kandi Protected Forests, Professional graziers	*2/-	*2/-	* 5/-		†7/13- per hundred	† 25/- per hundred			Working Plan 1948-49 to 1977-78 by M. G. Mohan
	*Fees collected by villagers				†Fees collected by the forest department				
Kangra Division : Professional graziers			Rs. 2/-		(a) *For residents* 1/9/- per hundred sheep and goats in Bara Bhangal 25/- per hundred goats and 7/13/- per hundred sheep in Dhaula Dhar (b *For migrants* 7/13-- per 100 sheep and 25/- per 100 goats in Bara Bhangal The rates in Dhaula Dhar are the same as for residents if the animals halt to graze; otherwise, none				Working Plan 1931-32 to 1950-51 by N.P. Mohan and Revised Working Plan, 1951-52 to 1980-81 by Romesh Chander, Simla, 1952
Kulu and Seraj Divisions :									Working Plan 1949-50 to 1979-80 by K. L. Aggarwal
Zamindars in their own *kothies*					1/9/- per hundred	2/5/6 per hundred			
Zamindars in high pastures outside in their own *kothies*					3/2/- per hundred	3/14/6 per hundred			

Table LXXVII—(*contd.*)

States	Cows	Bullocks	Buffaloes	Equines	Sheep	Goats	Camels	Elephants	Source and Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Foreign sheep and goats coming into Kulu					3/2/- per hundred	6/4/- per hundred			
Uttar Pradesh:									Silviculturist S. K. Seth, 1953 (1) (Rates for sheep, goats include watering) (2) The rates relate to Saharanpur division and are quoted as an exhaustive example
Privilege	-/1/6	-/1/6	-/3/-	-/1/6	-/1/6	-/1/6	8/-	120/-	
Non-privilege	-/2/-	-/2/-	-/4/-	-/2/-	-/4/-	-/4/-	8/-	120/-	
Jammuwala *gujjars*	-/14/-	-/14/-	3/4/- (lopping and *parao* inclusive)	-/6/-	-/4/-	-/4/-			
West Bengal		-/4/- per quarter	-/8/- per quarter		-/1/- per quarter	-/1/- per quarter			Bengal Presidency Forest Manual 1939 Dumsong Sub-Division Darjeeling Civil Division. (In Darjeeling reserved forests monthly rates vary from time to time)
PEPSU	1/2/-	1/2/-	2/4/-						Reply to I. C. A. R. questionnaire. (Rates apply to reserved forests only))
Rajasthan	-/4/- to 2/-	-/4/- to 2/-	-/8/- to -/12/-		-/1/- to 1/-	-/1/- to 1/-	2/- to 6/-		Mahendra Prakash (Rates vary from place to place.)
Madhya Bharat	Free	-/2/. to 1/-	-/3/- to 3/-	-/2/6 to -/8/-		-/2/- to -/8/-	-/10/- to 1/8/-	-/8/- to 10/-	Reply to I. C. A. R. questionnaire

Note 1. All rates are per annum unless otherwise indicated.
Note 2. *Punjab*—Cattle other than sheep and goats grazed in forests are those of right holders only and are allowed free.
Cows and buffaloes of non-right holders and professional herdsmen are grazed only in exceptional cases and then have to pay a fee either to the owners of the soil or the Government as the case may be.

TABLE LXXVIII

Statement showing the extent of loss in revenue on account of grazing rights and concessions in forests

State	Value of grazing revenue lost on account of rights and concessions	Revenue from grazing and fodder grass	Gross forest revenue	Values in col. 2 expressed as per cent of figures in col. 4	Figures in col. 3 expressed as per cent of figures in col. 4
	Rs. in lakhs	Rs. in lakhs	Rs. in lakhs	per cent	per cen
(1)	(2)	(3)	(4)	(5)	(6)
Assam	0.45	0.82	61.79	0.7	1.7
Bihar	1.29	0.05	32.31	4.0	0.2
Bombay	19.81	3.75	249.54	7.9	1.5
Madhya Pradesh	14.80	15.99	151.81	9.7	10.5
Madras	0.13	4.35	180.35	0.1	2.4
Orissa	1.56	0.14	21.90	7.1	0.6
Punjab	10.71	0.82	46.90	22.8	1.7
Uttar Pradesh	5.54	1.82	211.74	2.6	0.9
West Bengal	0.13	0.15	37.13	0.4	0.4
Hyderabad	...	9.51	82.70	...	11.5
Jammu and Kashmir	Not available	7.29	28.14	...	25.9
Mysore	0.11	0.56	63.57	0.2	0.9
P.E.P.S.U.	...	0.29	2.12	...	13.7
Saurashtra	0.15	1.05	3.65	4.1	28.8
Travancore & Cochin	Not available	0.36	114.52	...	0.3
Ajmer	0.21	0.04	2.13	9.9	1.9
Bhopal	0.72	1.27	6.62	10.9	19.2
Coorg	0.04	0.02	15.51	0.3	0.1
Himachal Pradesh	3.41	2.25	44.21	7.7	5.1
Kutch	0.01	0.03	0.05	20.0	60.0
Tripura	...	0.29	9.77	...	3.0
Vindhya Pradesh	...	0.97	37.99	...	2.6
Total	59.07	51.82	1404.05	4.2	3.7

The Andamans and Nicobars have been excluded as there is no grazing problem nor any revenue from grazing and fodder grass. The loss in 1947-48 on account of grazing rights and concessions amounted to Rs. 59 lakhs, that is, 114 per cent of the grazing revenue and 4.2 per cent of the total forest revenue.

The loss is greatest in the Punjab and Kutch, being 20 per cent more of the total state forest revenues. The loss is appreciable in Bombay, Madhya Pradesh, Orissa, Ajmer, Bhopal and Himachal Pradesh. Grazing revenue is a conspicuous item in Madhya Pradesh, Hyderabad, Jammu and Kashmir, P.E.P.S.U, Saurashtra, Bhopal and Kutch, less so in Madras, Himachal Pradesh, Tripura and Vindhya Pradesh.

Absence of adequate grazing in the forests, lack of accessible forests fit for grazing, exploitation of forests primarily for timber and preponderance of free or very cheap grazing may all account for a low grazing revenue ; the proportion of grazing revenue, therefore, does not always indicate the importance of forest grazing in a State. In Assam, West Bengal, Travancore-Cochin and Coorg, forest grazing is not a problem, and neither is the grazing revenue a significant part of the total forest revenue. In Bombay, Madras, Orissa, Punjab, Ajmer and Himachal Pradesh, on the other hand, forest grazing is a perpetual problem, of far greater significance than is indicated by the grazing revenue in those States. The low fees and excessive free and concessional grazing which largely account for the small grazing revenue are the factors which create the problem in these States. Once grazing is made more costly and rights and concessions are curtailed, the problem will vanish and the grazing revenue will increase more in proportion with the grazing burden carried by these forests.

Control of grazing incidence

Foresters have long stressed that the intensity of grazing should be limited to the carrying capacity of forests. The Cattle Conference of 1937 emphasized the need to limit forest grazing as regards quality and numbers of cattle ; it recommended that, as limitation of numbers is a necessary preliminary to limitation by quality, power to enforce limitation of numbers should be provided (Anon, 1937). The Fifth Silvicultural Conference considered that "effective limitation and full control over the numbers of cattle admitted to graze are essential preliminaries to any proper management of grazing, either in forests or in pasture lands, and that until these can be enforced, none of the benefits can be achieved which should be obtainable by better methods of management tested and proved by research". The Seventh Silvicultural Conference drew attention to the prevailing tendency to limit the powers of forest officers in the exercise of control over the grazing animal, and reiterated the need for limiting grazing incidence to utility cattle in accordance with the potential carrying capacity of the grassland.

The national forest policy also has laid down that regulation of the number of catt'e admitted is necessary for efficient forest management. In spite of this universal recognition of the need to limit the number of grazing cattle, it has been impossible generally to enforce any such limitations for reasons already stated.

It must be admitted, however, that no properly controlled experiments have yet been made to determine optimal grazing incidence. The best or optimal grazing incidence will be the maximum grazing incidence which can be permitted under local conditions of growth and treatment without causing deterioration of the pasture. This will vary according to conditions of soil, rainfall, amount of forest cover, system of closure, etc. Limits already adopted are purely arbitrary (Table LXXIX).

TABLE LXXIX

Arbitrary grazing incidence adopted by States

(Acres per animal)

State	Cow	Buffalo	Remarks
Bihar	2	...	
Orissa	4	6	
West Bengal	15		Kalimpong Division
		10	Jalpaiguri Division
Madras	2		Panchayat Reserved Forests
	2½		Rotational Grazing Scheme in Chittoor Forest Division (Krishnaswamy, 1939-40)
	3		Rotational Grazing Scheme in North Salem and South Cuddapah Division (Ranganathan 1937; Krishnaswamy, V. S , Continuous grazing)
	4		
	2½		Rotational grazing experiments on overgrazed pastures
Uttar Pradesh	1.5		South Kheri Division *sal* areas burnt annually
	2		South Kheri Division (others) (Avery, 1941)
	1		Grass Working Circle, Gorakhpur Division (Johri, 1948)
	2		Eastern Circle, poor grass areas
	1		Eastern Circle, good grass areas

Since 1915, grazing in Madhya Pradesh has been regulated in the reserved forests by a detailed village to village inquiry or grazing settlement by a Special Revenue Officer in conjunction with the Working Plans Officer. It classifies forests

for purposes of grazing control, and limits incidence for each class of forest (Nair and Sagreiya, 1944).

TABLE LXXX

Regulated grazing in reserved forests of Madhya Pradesh

Class of forest	Maximum permissible incidence (in acres per animal)
Tree forests :	
Moist type	4
Dry type	
(a) teak forests	2
(b) mixed forests	3
Scrub forests ;	
Pasture forests	1
Open pastures	No limit
(Note : The absence of any limit in this type of forest implies that practically all the cattle to which the privilege of grazing might apply in the reserved forests have been provided for)	
Miscellaneous :	
Grass reserves, village sites, etc.	No grazing

The scale of incidence for various types in Madhya Pradesh illustrates the ecological fact that the more of a woodland an area is, the less grass it contains. Kumar has, however, graded carrying capacity in terms of rainfall (1946) in an exactly opposite way.

Rainfall (Inches)	Acres per animal
Above 100	$\frac{1}{2}$ to $\frac{3}{4}$
50 to 75	1 to $1\frac{1}{2}$
35 to 50	2 to $2\frac{1}{2}$
25 to 35	3 to 4
Below 20	4 to 5

This will apply where grassland is maintained artificially in a woodland climate under a regime of deliberate regression, but certainly not when progression goes on relatively unhampered.

The grazing incidence characteristic of the different types of forest in Uttar Pradesh is as follows (Seth. 1953) :

Description of forest	Grazing incidence
Moist savannah	Control neither required nor enforced ; incidence reaches 6·4 animal units per acre in places
Dry pastures	3 to 4 acres per cow unit optimal
Coniferous forest	Unrestricted
Sal forest	Less than 2 acres per cow unit
Submontane miscellaneous forest	Rarely exceeds 2 acres per cow
Coppice, scrub and thorn forest	Up to 1 acre per cow unit ; 4 acres per cow unit obligatory in Protection Working Circle
Ravine lands	2 acres per cow unit

Mere restriction of numbers of cattle in a forest will not be enough ; the peripheral areas are generally overgrazed even where cattle numbers are limited. A directive to the divisional staff to ensure uniform distribution of grazing incidence over the whole area is embodied in some working plans of forests in Bihar (Mooney, 1936-37) ; the distribution may be ensured by prescribing monthly grazing blocks. The fixing of grazing units at the time of grazing settlement in Madhya Pradesh suggests that the need for proper distribution of grazing is recognized.

Limitation of grazing incidence can be effected in two ways : directly by executive order, or indirectly by economic pressure through fees. The first method enables exercise of full control, the second is less certain and not immediate in effect. Bihar, Orissa, Uttar Pradesh, Madhya Pradesh, West Bengal and parts of Madras would appear to exercise direct control over forest grazing incidence

through prescriptions in Working Plans or provisions in grazing rules. In most other States, not excluding the politically advanced States of Bombay and the Punjab, no such direct control is exercised. As for the indirect one of enhancing the grazing fee, this is no less difficult to apply in the early days of democracy; in the struggle for power among political parties, it is liable to be misrepresented "as a species of provincial tax, rather than as the price of goods consumed" (Ranganathan, 1937). It is, however, a fact that increased grazing fees will go a long way to limiting grazing incidence in terms of numbers and quality; unless they are worth it, cattle will not be grazed in forests. The national forest policy has stressed this method of grazing control.

Wherever a grazing incidence is prescribed in the Working Plan or in the grazing rules, it is generally expressed in terms of a cow or bullock unit at so many acres per unit. Variations in fee for different animals generally reflect the prevailing impression of the intensities of grazing of different kinds of cattle. Specific ratios are in vogue in some States. In Madras the proportion usually adopted has been 1 cow or bullock = ½ buffalo = 2 sheep (Government of Madras 1946, and Krishnaswamy V. S. and Venkataramana Reddy, 1953). A cow over 3 years not in milk was taken as a cow unit. Other kinds of cattle were correlated to this unit as follows:

	Cow Units
Working buffaloes and milking buffaloes	2
Working bulls, milking cows, ordinary buffaloes other than working buffaloes and milking buffaloes	1½
Other bulls, and cows and horses	1
Young buffaloes	¾
Young cattle	½
Sheep and goats	⅓

This scale has, however, not yet been adopted in forest grazing control.

In Uttar Pradesh the following scale is adopted (Seth, 1953) :

	Units
Cow, bull, bullock, heifer or steer	1
Buffalo (mature)	2
Buffalo (young)	1
Horse, pony, mule, donkey	½
Sheep or goat	¼
Calves below 1 year old	-*nil*-

Wherever a maximum grazing incidence is enforced, it is recommended that excess cattle should be excluded on a rational basis (Krishnaswamy V. S. and Venkataramana Reddy, 1953), distinguishing also between local cattle and foreign cattle. Even among local cattle, essential and non-essential cattle should be differentiated. Under non-essential cattle those maintained for quasi-agricultural or domestic purposes such as for milk and milk-products and manure should be distinguished from cattle maintained for commercial purposes. The order of preference for admission in the forests should be: essential cattle, non-commercial local cattle, commercial local cattle and foreign cattle ; these classes are excluded in the reverse order. This principle is accepted in Madhya Pradesh. Four animals per working plough are treated as essential or privileged cattle, an equal number as ordinary cattle, and additional ones as commercial cattle ; but as grazing incidence is unlimited in the 'open pastures' type of forest, there is in effect no exclusion of cattle which are in a position to utilize forest grazing (Nair and Sagreiya, 1944).

The Madras Special Grazing Officer's proposals approved in 1942 prescribed the following scale of essential cattle (Krishnaswamy V. S. and Venkataramana Reddy, 1953) :

Area of holding (acres)	*Essential cattle* (Units)
Up to 2	2
2 to 5	3
5 to 10	4

Discussing this provision, Krishnaswamy and Venkataramana Reddy have pointed out that on this basis one unit of cattle per acre of cultivation will be permissible ; as the entire cattle population of the State is only 75 animals for every 100 acres of cultivated land, there would be no occasion for exclusion. When a distinction is made in these circumstances between essential and non-essential cattle, the latter could easily be passed off as essential ; the proper course would be to depend on enhanced fees to control incidence.

In Bombay, the following order of priority would appear to have been adopted for the admission of cattle into forest blocks :

(1) Cattle of villages surrounded by forest ;

(2) Cattle of villages near forest, but not altogether surrounded by it ;

(3) Cattle of non-forest villages in the *taluk* or range, the nearest village having the first claim ;

(4) Cattle of another *taluk* or range ;

(5) Non-village cattle of the district ; and

(6) Cattle of another district.

Any such differentiation has apparently no place under the present conditions of uncontrolled free-grazing in that State.

Control of grazing incidence appears to be quite strict in the forests of West Bengal. In the upper forests of Kalimpong division, grazing is reserved for cattle owned by tenants of Government at the rate of two head of cattle per acre of land held. In Jalpaiguri division, the villages having the privilege of grazing and the number of cattle are decided by the Deputy Commissioner. In Buxa division, only cattle of neighbouring villages are permitted, while those of professional graziers are debarred. On the whole, the general tendency is to give priority to cattle needed for bona-fide agricultural and domestic requirements, but, except perhaps for Bengal and parts of Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, and Madras, the priority is meaningless as no effort is made to control grazing incidence.

Closure in forests in relation to grazing management

Under certain circumstances, forest areas are closed to grazing and the exercise of other rights of user for varying lengths of time. Such closures are

Table LXXXI

Relative proportion of forest areas closed to grazing

State (1)	Total area of forests under the control of Forest Departments (2)	Area closed to grazing to all animals throughout the year (3)	Extent of closure expressed as a percentage of total forest area (4)
	Square miles	Square miles	Per cent
Assam	20,948	4,117	20
Bihar	2,381	357	15
Bombay	11,818	1,060	9
Madhya Pradesh	19,422	1,944	10
Madras	15,906	1,664	10.5
Orissa	2,874	477	15.9
Punjab	3,878	190	4.9
Uttar Pradesh	10,209	1,555	15.2
West Bengal	2,673	2,506	93.8
Hyderabad	9,466	2,694	28.5
Jammu and Kashmir	11,053	533	4.8
Mysore	4,443	99	2.2
P.E.P.S.U.	238	40	17
Saurashtra	631	28	4.4
Travancore-Cochin	3,065	191	6.2
Ajmer	73	36	49.3
Bhopal	1,217	40	3.3
Bilaspur	200	7	3.5
Coorg	834	19	2.3
Himachal Pradesh	2,862	78	2.7
Kutch	156	...	...
Tripura	3,610	...	...
Vindhya Pradesh	8,000	291	3.6
Total excluding States for which full data are not available and Andamans.	122,196	17,926	14.7

Note : Figures in col. 2 are from col. 6 of Statement II of "*Indian Forest Statistics*, 1947-48" published in 1952. Figures in col. 3 are from col. 2 of Statement X of the same publication.

generally punitive or silvicultural in scope and, less commonly, done to improve grazing.

(1) *Punitive closures* : These have been referred to under Forest Laws. Both the Indian Forest Act and the Madras Forest Act have authorized suspension of grazing and other rights in a forest for a suitable period when a fire is caused there wilfully or negligently. Because of the inconvenience imposed on right holders, the measure is calculated to be a corrective or deterrent against incendiarism. Such closure, however, is necessary in the interest of silviculture also ; if cattle are allowed to enter soon after the vegetation has been burnt by fire and the soil exposed, considerable erosion will occur and much damage done to any new regeneration which may be coming up. These closures should be enforced immediately after fire if they are to be effective both as punitive and silvicultural measures. In practice, maps showing incidence of incendiarism are maintained. When it is found that particular areas are burnt regularly, immediate steps are taken to close such areas. In Madras, when fires occur near cattle pens inside forests, the pens are also closed (Krishnaswamy V. S. 1941-42). Exceptionally in some areas, as on the Nilgiris and Palnis, annual burning of grasslands has been permitted as a concession. Burning in these areas is necessary if they are to be maintained as pasture lands. Some of the coarser perennial grasses assume a depauperate form when subjected to burning and grazing, and become at least partly edible. Closure generally helps the consolidation of perennial grasses which are fibrous and inedible. As growing trees and conserving the soil have priority over grazing in forests, punitive closure in case of incendiarism is justified ; it lasts generally until the end of the grazing year, or longer if silvicultural considerations make it desirable. In Ajmer, burnt-over areas are closed for four years. Mohan observes, with particular reference to the Punjab, that punitive closures are extremely difficult to enforce if the local population is hostile ; a good deal of discretion is needed in enforcing such closures. He agrees, however, that there are cases in which such closures are inevitable. (Mohan, 1954).

(2) *Closures for silvicultural reasons* : Steep slopes and areas liable to severe erosion may need to be permanently closed to grazing. Geologically, the whole of the Siwalik foothills and much of the Salt Range upland are so unstable that any form of grazing is bound to have serious consequences (Gorrie, 1946). Grazing should be eliminated altogether in such areas and replaced by stall-feeding. In the Punjab, such closures are possible under the Land Preservation (Chos) Act

of 1902, though, as a practical proposition, they have proved impossible (Mohan, 1954).

In the case of coppice coupes, natural regeneration areas and in plantations, tree seedlings and saplings have to be protected against browsing and other forms of damage by cattle. Grazing in such areas is, therefore, pro ibited until the plants grow beyond the reach of cattle. These temporary closures incidentally help the growth of grass wherever ecological conditions are favourable. There is generally a great demand for cutting grass and pasturing in such areas, but subsequent continuous, unregulated grazing nullifies whatever recovery has been effected by closure. In Darjeeling Division of West Bengal, the Divisional Forest Officer may, at his discretion, close areas in which grazing or fodder cutting is doing much damage. The Divisional Forest Officer, Saranda Forest Division, Bihar, has similar powers. No grazing is permitted in this Division in coupes less than ten years old. In Santal Parganas, coppice coupes are closed for eight years and plantation areas for all time.

In Nagpur—Wardha of Madhya Pradesh, it is general practice to close an area for about ten years after fellings. The Conservator may open the area earlier if the plants have grown beyond the reach of the animals. In Yeotmal Division, coppice coupes of 40 years' rotation are subjected to periodic closures as follows : six years closed, fourteen years open, three years closed, seven years open ; in High Forest Working Circle, the closure prescribed is five years after working in each coupe in the regeneration block. Agri-silvicultural plots and plantations are closed to a maximum of ten years at a time. In Melaghat Forest Division, worked coupes are closed for ten years. In Buldana Forest Division, the following periodic closures have been fixed in teak working circles :

Rotation for teak:	
40 years	5 years closed plus 15 years open plus 5 years closed plus 15 years open
30 years	4 years closed plus 11 years open plus 4 years closed plus 11 years open

In Selection-cum-Improvement Working Circles with a felling cycle of 30 years, a closure of 10 years followed by grazing during the rest of the cycle has been prescribed. In Bhandara Forest Division, closures are for seven years after main fellings in High Forest Working Circles and Coppice Working Circles and 10

years in teak plantations. In North Raipur Division, the regeneration block in Teak and Sal High Forest Working Circles and plantations in Plantation Working Circles are closed for 10 years and coupes of Selection-cum-Improvement and Coppice with reserve Working Circles for seven years.

In Coorg, new plantations are closed to grazing for a term of six years. In Ajmer, coupes are generally closed for ten years but the period may be extended for a further period of ten years if necessary.

In Nilgiris Division of Madras, teak plantations, fuel coupes, *Sandal* plantations and special tending areas in Selection Working Circles are closed for ten years (Ranganathan, 1941). In North Coimbatore Division, fuel coupes are closed for a period of five years (Ranganathan, 1934).

In Uttar Pradesh, regeneration blocks of *Sal* Working Circles and *sal taungya* areas are all completely closed to grazing. In Bundelkhand all coppice coupes are closed to grazing for five years after fellings. Plantations raised after clear felling, or *de novo*, are closed to grazing for five or more years. Grass-cutting may be allowed during the closed period (Seth, 1953).

In the Kangra District, excluding Kulu Sub-division, in the Punjab, there is a scheme of rotational closures for protection forests. Under this scheme one-third of the scrub forests can be closed for ten years in rotation, each coppice coupe getting 10 years protection. In all other forests, viz. chir, oak, fir and spruce forests, one-fourth of the area can be closed for 30 years in rotation. This results in a system of fixed periodic block with a fixed period and a fixed rotation. A divisional forest officer can, however, permit grazing before the expiry of the closure period if the condition of the regeneration warrants it (Mohan, 1954).

In Bombay, closures of five years for Casuarina and *Babul* Working Circles and ten years in Main Timber and Pole Working Circles appear to be practised in Thana forests. For Igatpuri forests of East Thana Division, the following system of periodic closures has been prescribed :

Teak Working Circle. 50-year rotation	Close 6 years plus open 10 years plus close 2 years plus open 8 years plus close 2 years plus open 10 years plus close 2 years plus open for 10 years
Semi-evergreen Working Circle, 40-year rotation	Close 6 years plus open 15 years plus close 2 years plus open 8 years plus close 2 years plus open 7 years

In Nasik Above-Ghat Working Plan, closures prescribed are 7 years in Teak Working Circle, ten years in *Anjan* (*Hardwickia binata*) felling series of scrub Working Circle and 5 years in the remaining scrub Working Circle. In Kolaba, Teak timber, Teak pole and Fuel Working Circles are all closed for five years after felling.

In Sambalpur East Division of Orissa, all coupes are closed for ten years, three years before felling, one year during felling and six years after felling. In some Orissa States, areas under regeneration in High Forest Working Circle are closed for five years and coupes in Pole Working Circle for ten years—five years before felling and five years after felling. In Russelkonda Division, the closures are for three years after main fellings in Selection coupes, ten years in clear-felled areas, plantations, regeneration blocks and coppice coupes of 60 years rotation and six years for coppice coupes of 40 years rotation.

In Hyderabad, closure of coupes and plantations for ten years after felling or regeneration is practised. In Madhya Bharat, teak coupes are closed for five years and *Anjan* coupes for seven years. Closure for eight years in plantations and six years in coppice coupes is practised in Shencottah Division of Travancore-Cochin. In Mysore State, coupes and regeneration areas are closed for at least five years.

In Madhya Pradesh and Bombay, closures are sometimes done with a view also to the improvement of grazing. The cycles involve a few years of closure followed by some years of grazing. While the closure does often improve the grazing by replacing the weeds and unpalatable grasses by superior grasses, much of the advantage is soon lost as a result of very heavy incidence of grazing after re-opening the area. These periodic closures do, however, benefit the tree growth considerably.

(3) *Closure for improvement of grazing :* Control of grazing incidence generally serves merely to conserve and prevent further deterioration of grazing in pasture lands. Where the grazing has to be improved appreciably, as in areas overgrazed in the past, some form of closure is essential, for durations which will depend on circumstances. Grazing under closures enforced at regular intervals may be (a) periodic, (b) rotational, and (c) deferred (Sah, 1938).

(*a*) *Periodic grazing* : Grazing of a limited number of cattle for a definite number of years or months followed by closure (Sah, 1938). The closure is itself called periodic closure and is often for periods of a year or more at a time.

(*b*) *Rotational grazing* : Restricted grazing rotating over units of the entire area (Sah, 1938). Rotational closures are for short terms of a week or a month or more at different seasons of the year.

(*c*) *Deferred grazing* : Grazing a part of the area in turn, the plants in one portion being allowed to mature their seed each year before the stock is admitted (Sah, 1938).

Temporary closures practised in coupes, plantations and regeneration areas throughout the country result in periodic grazing, though their object is often primarily silvicultural.

From the grazing point of view, periodic closures are not generally beneficial because (*a*) closure beyond a certain period does not lead to further improvement of the grasses, and (*b*) if the grasses are not cut or allowed to be grazed but are left to rot, the quality and quantity of the grasses themselves deteriorate. There is, however, likely to be some improvement in the grass stand after closure, but this is soon lost due to the continuous and often unrestricted grazing that follows. Experience in Uttar Pradesh has shown that, when a closed area is reopened to unrestricted grazing, reversion to the original worthless grasses, *Aristida hystrix* and *Aristida depressa*, and the almost complete disappearance of valuable fodder grasses are very rapid (vide proceedings of the Board of Forestry, 31st October to 3rd November, 1942). These closures, in any case, benefit tree species which germinate and become established in large numbers. The rapid deterioration of grazing in reopened coupes may be prevented by controlling grazing incidence. Wilson demonstrated in Madras how such reopened coupes can be formed into grazing units and successfully worked under a system of rotational grazing.

In addition to periodic grazing incidental to silvicultural closures, Uttar Pradesh, Madhya Pradesh and Bombay have worked out a number of periodic grazing schemes. In Uttar Pradesh, the following schemes of periodic grazing, based on an incidence of grazing of two acres per cow, have been attempted :

(1) Annual closure of the whole block for two months in the rains (July and August) each year, and grazing during the remaining ten months.

(2) The grazing block is divided into three more or less equal sub-blocks, two of which remain closed in the monsoon, while one remains open in the period. In the winter and summer, two sub-blocks are opened while one sub-block remains closed for all the 12 months—3-year cycle.

(3) The grazing block is divided into two sub-blocks, one of which remains open in winter and summer, while the other remains closed throughout the year. The whole block is completely closed in the rains (July and August) every year—2-year cycle.

(4) The grazing block is divided into three sub-blocks, one of which remains open in winter and summer while the other two are kept closed; the sub-block opened in winter is, however, closed during the rains; the whole arrangement is in rotation—3-year cycle.

(5) The grazing block is divided into four sub-blocks, of which only one remains open during the rains, while the other three are opened in winter and summer, the whole arrangement in rotation—4-year circle.

(6) The grazing block is divided into four sub-blocks, only one of which is opened in the rains and two in winter and summer. The fourth remains closed throughout the year; the whole arrangement in rotation—slightly different from No. 2—3-year cycle.

The following results are recorded :

(1) Closure for only a few months during the monsoon improves the quantity and quality of the fodder grasses while the indigenous tree and shrub-growth also benefits by protection. Superior fodder grasses recuperate, seed properly, regenerate and extend naturally, while surface erosion is arrested by one year's effective preliminary closure followed by closure during the rains.

(2) Grazing in winter and summer does not have an injurious effect on grass growth, provided the limiting incidence is not exceeded.

(3) Grazing under control combined with closure during the rains followed by one or more cuttings of grass does not cause any appreciable deterioration in quality and quantity of the grass yield. Periodic grazing for eight months combined with the monsoon closure is definitely preferable to rotational grazing for one month followed by three months' rest in rotation throughout the year.

In 1938, Sah (1938) suggested the following schemes of periodic grazing :

A. Grazing area is divided into three compartments and the following scheme of closure, cutting and grazing on a 3-year cycle is followed, based on a limiting incidence of two acres per cow :

Compartment	1st year		2nd year		3rd year	
	Rains (July to October)	Winter and summer (November to June)	Rains	Winter and summer	Rains	Winter and summer
1	Grazed	Grazed	Cut	Grazed	Cut	Grazed
2	Cut	Grazed	Grazed	Grazed	Cut	Grazed
3	Cut	Grazed	Cut	Grazed	Grazed	Grazed

B. Area is divided into two compartments and worked as follows on the same limiting grazing incidence :

Compartment	1st year		2nd year	
	Rains	Winter and summer	Rains	Winter and summer
1	Grazed	Grazed	Cut	Grazed
2	Cut	Grazed	Grazed	Grazed

Raynor has observed that the scheme B is the simplest and the least restrictive that could be devised and has proposed its adoption for initial regulation of grazing in future. Much as monsoon closures are desirable, they are difficult to enforce because cattle seek forest grazing more especially during the rainy season when the village fields carry agricultural crops. Biennial closures are a way out of this difficulty.

In the Protection Working Circle of Bundelkhand, in Uttar Pradesh, grazing is permitted under a system of periodic closures, i. e. two years grazing followed by two years closure. In the ravine lands a system of 16 months continuous closure, *viz.* four monsoon months, eight winter and summer months and four monsoon months of the next year—followed by 32 months continuous grazing on a four-year cycle had been in vogue till recently. As this involved creation of four grazing blocks, which were found difficult to manage, it has now been replaced by a scheme

which divides each grazing area into two blocks and allows two years consecutive monsoon closure in each block alternately. The blocks are open to grazing during the rest of the year (Seth, 1953).

In the Pasture Working Circle of Buldana Forest sub-division in Madhya Pradesh, the Working Plan (1938-39 to 1947-48 by S. A. Cornelius) prescribed a rotation of three years closed and 12 years open. After the removal of cut grass, the coupes under closure could be opened to grazing of a limited number of cattle from the first December at the discretion of the Divisional Forest Officer.

The scheme of periodic grazing prescribed for the Pasture Working Circle in Thana Forest, Bombay State, (Working Plan by H. W. Starte, 1935) is as follows: Area is divided into five felling series. Each felling series is divided into five sub-blocks, each of four coupes. The sub-block is the unit of grazing. During the 20-year felling cycle, one sub-block will be closed continuously for four years, and during that period the remaining four sub-blocks will in turn remain closed during the rains, viz. 1st June to end of October. Thus during the 20-year felling cycle, each sub-block will get one long continuous closure of four years and four short intermittent closures during the monsoon months only. The sub-block closed for four years is maintained as a cutting *kuran* to supply grass for stall-feeding,

In the Satara district of Bombay, two projects known as the six-pasture and four-pasture schemes were started in 1942 and 1944-45 respectively. The objective in both is to get part of the area closed for full improvement, to use part as special grazing grounds for working cattle, and to have rotational grazing for non-working cattle in the remainder.

In the six-pasture scheme, a grazing area of 7,491 acres is divided into felling series, and each felling series into six ranches, each having six pastures. Every year one pasture in each felling series comes under complete closure and will remain closed until the next pasture in the same ranch comes up for closure. Successive pastures in each ranch are closed at intervals of six years and the whole felling series is covered in 36 years.

One ranch is taken up each year and treated as follows: One pasture will be closed to grazing. If it contains tree growth, it may be felled to the extent desired. Improvements by contour trenching, contour ridging with stones, gully plugging and *nala bunding* are carried out. Where contour trenching is done, tree growth is introduced. Between the contour trenches, grass sowing and tuft plant-

ing will be done. One pasture will be reserved for the working cattle and four pastures wil be reserved for rotational grazing by allcattle. For this purpose the rainy season is divided into two periods, (*a*) from 15th June to 31st July, and (*b*) from first August to 31st October. Two pastures are allotted for each period ; the two grazed first in one year will be the ones grazed last in the next year. From the first November until the 14th June, all four pastures plus the pasture reserved for working cattle will be open for general grazing.

The four-pasture scheme covers a larger area (27,136 acres). In it, each felling series has nine ranches and each ranch has four pastures. One pasture is closed for improvement, one allotted for working cattle and two for rotational grazing. The closure is increased from six to nine years. The improvement is carried out on a rotation of 36 years as in the six-pasture scheme.

The two schemes appear to have been worked until 1949-50. The Forest Administration Report of Bombay State for 1950-51 states that work was discontinued due to lack of funds ; only repairs to trenches and *bunds* and cultural operations were done.

The results of experiments carried out by Dr. Burns in Bombay between 1926 and 1931 were made early use of in Madras. Ranganathan's Rotational Grazing Scheme for North Salem Division was perhaps the first of its kind in the country. Two penning sites with assured water supply were the location of the scheme. Pens were selected for the purpose, as the Department could freely limit stock numbers and watch and control the movement of known numbers of cattle over prescribed areas for definite periods. The capacity of each pen was fixed at 1000 cow units ; on a liberal allowance of three acres per cow, a rotation block of 3000 acres was allotted to each pen. Each rotation block was divided into three paddocks of more or less equal area. The penning was to be from first June to the end of January, following local practice. Each paddock was to be grazed in rotation for a period of one month and rested for two months. A rotational burning was also to be done in January every year with the idea of eliminating tall and tough grasses Each year a survey of the grasses was also to be made to record changes (Ranganathan, 1935). As Special Grazing Officer, Wilson took up this idea of making penning stations (pentas) the sites for rotational grazing and recom-

mended it under Penning Block system in his report (Krishnaswamy, V. S. and Venkataramana Reddy, 1953).

M. H. Krishnaswamy has prescribed for Kurnool East Division a scheme of rotational grazing in 1,200 acres of recently felled fuel coupes grouped to form three paddocks. Four hundred cow units fixed on a limiting incidence of three acres per cow unit are grazed in one paddock at a time rotationally. Grazing is not allowed for more than a month at a time in any paddock and a paddock once grazed should not be grazed again for at least six weeks. In his working plan for Chittoor Forest Division (1939-40), V.S. Krishnaswamy had prescribed a similar scheme of rotational grazing in four blocks comprising recently felled coupes, each block being divided into three paddocks and each paddock grazed in turn for one month at a time. Under this Working Plan was also organised for the first time a scheme of deferred-cum-rotational grazing on a experimental basis. The scheme was based on the results of experiments done elsewhere which had shown that mere closure to grazing resulted in improvement of pasture up to the fourth year only and that for subsequent improvement some form of treatment amounting to a reseeding was necessary. If an under-stocked pasture is allowed to come to seed and is then grazed fairly heavily, the seeds are spread about and trodden in by the cattle. They germinate with the next rains and the pasture improves considerably. Rotational grazing may begin at this stage. An area of 250 acres comprising four fuel coupes felled a few years previously and closed after felling was used for the experiment. By 1st February, 1939, the grass in the area had seeded well. From that date, each of the coupes was successively grazed by 250 head of cattle in ten days, the grazing being completed in 40 days. In the area on which the grass seeds had germinated after the rains, rotational grazing was to be enforced, with the following specifications :

(a) Grazing incidence was fixed at two and a half acres per cow unit, or 100 cow units for the whole area.

(b) Cattle were to be treated as one herd and moved from paddock to paddock as a single unit, each coupe forming a paddock.

(c) When grazing was available and the rotational grazing started, the cattle might enter any one of the paddocks and graze for not more than one

month. They were then to move to another paddock. The move from one paddock to another might be made before a month, but the cattle were not to return to a paddock already traversed for a period of six weeks.

(*d*) Manure should not be removed from the area (Krishnaswamy, V. S. 1939-40).

The idea behind this scheme was embodied by Wilson in his Special System (Krishnaswamy V. S. and Venkataramana Reddy, 1953). The object was to segregate exceptionally good grazing areas near villages and to manage them intensively for the use of good quality animals. The areas were mostly to comprise recently felled fuel coupes carrying a good stand of grass as a result of closure. To retain the improvement, deferred and rotational systems of grazing were suggested. Each year more fuel coupes were to be brought under the system as fellings proceeded and ultimately the whole fuel working circle, a considerable area forming a peripheral strip, was to come under this Special Block. This system of deferred and rotational grazing has also been proposed by V. S. Krishnaswamy in Anantapur Working Plan (1941-42 to 1955-56).

The rotational and deferred-cum-rotational systems of grazing are becoming increasingly popular in Madras. According to the Forest Administration Report of the State for 1950-51, the rotational system was continued in Guntur, Chittoor, Salem North and Cuddapah South Divisions over an area of 70,794 acres, while deferred and rotational grazing was continued in all the divisions except Tirunelvely over an area of 42,014 acres. Their operation appears to have been satisfactory in all except Chittoor and Kollegal Divisions. The position appears to have improved further in 1952.

According to the Madras Government Order No. 4470, dated 21st October, 1952, Dev. on the report of special officers (V. S. Krishnaswamy and T. Venketaramana Reddy, 1953), 129 rotational grazing blocks covering an area of 130,773 acres in nine forest divisions were then functioning and 23,476 cow units were being grazed in these ways. The system still requires to be extended further, but compared to what the other States have done, this is quite a phenomenal achievement.

In Bombay, a scheme of rotational grazing is stated to have been in force in East Khandesh since 1930. Each compact grazing area is divided into convenient blocks ; each block is sub-divided into five compartments, each of which

receives the same treatments on a five-year cycle, as follows :

Year	Open	Closed
1	15th June to 31st August —2½ months	1st September to 14th June—9½ months
2	1st November to 14th June —9½ months	15th June to 31st October—4½ months
3	1st September to 14th June —9½ months	15th June to 31st August—2½ months
4	15th June to 14th June —12 months	
5	15th June to 14th June —12 months	

Two out of the five compartments are closed each year during the rains. The cycle is superimposed on a 30-year felling cycle for coppice poles and fuel.

A slightly more complicated scheme devised by Garland appears to have been tried in West Khandesh Division from 1938. The felling series is divided into five blocks. A newly felled area is allotted to block I and closed for eight years. The other four blocks are grazed with rotational six-weekly closures during the rains ; half of them are open and half closed during the rains, all except block I being open from November to mid-June. These schemes do not appear to have been expanded, or even maintained. For a State which had successfully carried out experiments on rotational grazing and showed the way to other States, Bombay has practised very little grazing regulation.

Rotational grazing in Uttar Pradesh was introduced in 1937 in an area of 2,800 acres in the Fisher Forest on an incidence of two acres per cow. Cattle were moved from block to block at short intervals ; in order to prevent the same block being grazed during the rains every year, the rains grazing was started in different months. There was marked improvement in the grass stands in the blocks and in the condition of the cattle by 1938.

Uttar Pradesh has carried out some important experiments in rotational and

periodic grazing in arid and *usar* areas, where in particular in that State grazing is a serious problem. The conclusions from these experiments have already been mentioned under periodic grazing. The indications are that, for arid and *usar* areas, simple schemes of periodic grazing with monsoon closure would be feasible. Periodic grazing for eight months with closure during the monsoon is preferable to continuous rotational grazing for one month at a time followed by three month's rest. Periodic grazing with biennial monsoon closure is the scheme now favoured.

Working Plans in Bihar had even in 1939 proposed rotational closures during monsoon months, but it is not known how far these have been implemented.

In Jalpaiguri Division of West Bengal, the Working Plan (1942-43 to 1956-57) has prescribed a rotational grazing scheme. A belt of forest about two to three miles wide along boundaries and excluding riverain areas was divided up into a suitable number of grazing units. Each unit is sub-divided into three grazing blocks or pastures using existing compartment lines. The number of cattle is fixed with reference to the area of the smallest pasture, allowing five acres of each for cows and ten acres each for buffaloes. Each pasture has a serial number and is grazed in turn for a month only at a time. Thus in six months of the dry season each pasture will be grazed twice. In the following year the cycle will start in a different pasture. Each pasture will thus be rested in different months on a rotation of three years, thus ensuring rotation both in time and space.

Beyond the inconclusive experiments carried out in Yeotmal and Nagpur Divisions and periodic closures practised in coupes, plantations and regeneration areas, no rotational grazing as such appears to be practised in Madhya Pradesh. It is, however, gathered from a paper by Lakhpat Rai (1951) that Working Plans recently revised and those under revision have prescribed periodic and monsoon closures and the constitution of Pasture Working Circles wherever feasible and the people consent. The prescriptions of this working circle include, among others, a limiting incidence of one acre per cattle unit, monsoon closures and prohibition of grass cutting in the closed area during the monsoon.

In the face of the heavy demand for grazing, the deferred system is not practicable. As even monsoon closures are resented by people if done every year, biennial closures have to be adopted. Deferred grazing implies closure for some time even after the monsoon is over until the grass seed matures, and is, therefore, out of the question as a regular practice. As in Madras, it is adopted only when a deteriorated pasture needs to be rehabilitated. The grasses are allowed to seed

and the seeds worked into the soil by allowing cattle to graze just when the seeding is over. A combination of deferred and rotational grazing is becoming increasingly common in Madras. On the whole, the present trend in grazing management is initial closure to grazing to give a chance to the better grasses to reappear, and then exploiting the grasses initially by grass cutting and light grazing, subsequently by rotational and deferred grazing (Banerji, 1953). Madras is much ahead of other States in applying rotational grazing.

In the Punjab, the administration is seriously handicapped by the existence of an over-abundance of grazing rights and any kind of rotational grazing is impossible. Periodic silvicultural closures are all that can be practised. In the areas so closed, there is abundant growth of grass, and cutting is permitted. Some good work has been done by securing voluntary closures. Applications for closures under Section 38 of the Indian Forest Act are obtained through propaganda. Compulsory closures under the Land Preservation (Chos) Act are also imposed wherever necessary. In Kangra, for every working scheme of Kangra Forest Societies, there is a grass and fodder working circle which is divided into two or three blocks and each block is closed for ten years at a time. During the period of this closure, trees of fodder value and grass species are introduced (Mohan, 1954). The Forest Administration Report for 1950-51 shows that closures have led to a vast improvement in the quality and quantity of grasses and other vegetation. Large quantities of grasses are now available for stall-feeding.

The percentage of forest area closed to grazing in each State is given in Statement LXXXI. Apart from States like Coorg and Travancore-Cochin whose forests carry superior tree growth and are characterized by very low grazing incidence, the percentage of closure indicates in a general way the extent of control exercised on forest grazing. There is very little closure in the Punjab, Kashmir, Mysore, Saurashtra, Bhopal, Bilaspur, Himachal Pradesh and Vindhya Pradesh. Among States whose forests provide appreciable amounts of grazing, Madhya Pradesh, Madras, Orissa, Uttar Pradesh, Hyderabad, P.E.P.S.U. and Ajmer enforce an adequate degree of closure.

CHAPTER XIII

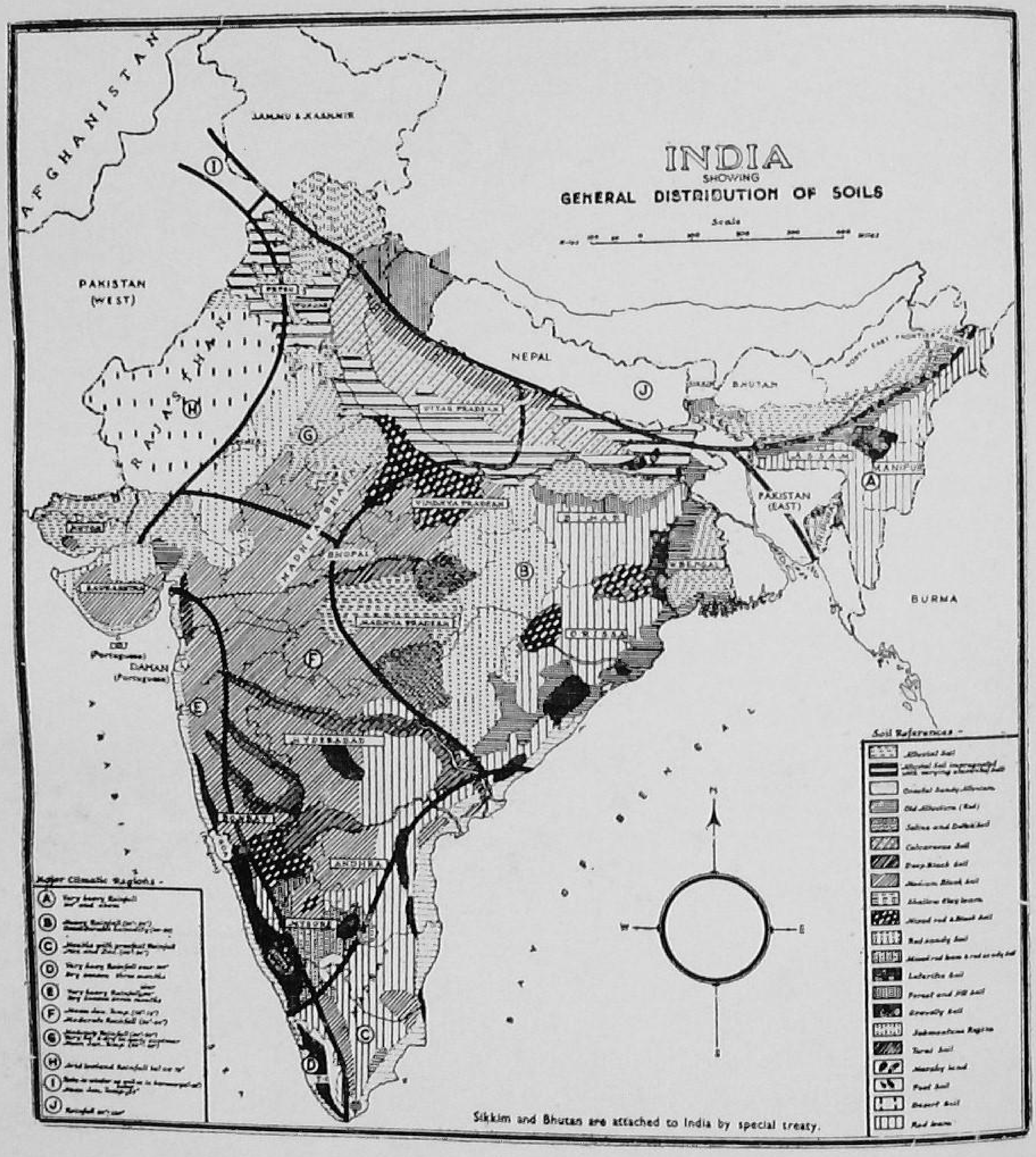
SOILS AND FERTILIZERS

Soil types

In order to indicate briefly the various types of soils found in India, the general classification made by the Indian Agricultural Research Institute for undivided India and used by Stewart (1947) is quoted here.

"*Red Soils.* Lateritic soils and red soils of varying texture occur extensively in many parts of India, but particularly in the eastern and south-eastern portions of the country. These red soils are generally relatively light in texture, porous and friable. *Kankar* or other forms of free calcium carbonate are absent and the soluble salt content is usually low. The red soils differ greatly in depth and fertility from place to place, and produce a large variety of crops under both irrigated and rain-fed conditions. Local variations in colour are common, and in many areas it is possible to trace a sequence from yellow to red, to brown and dark brown, merging often into the black soils within quite short distances. Cultivation may alter the colour of a soil, e. g. from red to dark brown or even to black, in a relatively short time, and colour by itself may not, therefore, be a reliable characteristic on which to base the differentiation of soil types. Many of the red soils are formed *in situ* and, in this respect, appear to differ from their geographical neighbours, the black soils, which are often derived from the same geological parent material but which are more cumulose in origin. These red soils as a group differ from most of the other soil types in India in one respect which is of considerable importance to agriculture, viz. their lime and phosphate contents. Whereas most of the other soil types are usually alkaline in reaction, and contain varying amounts of free or uncombined calcium or other carbonates, the red soils are generally neutral or acid in reaction, and are relatively lower than the others in lime and phosphate.

"Laterites, which constitute a distinct class of red soils, are usually well-drained and porous, and are specially well-developed on the summits of hills in the Deccan, Mysore, Travancore, Central India, Central Provinces, Raj Mahal, the Eastern Ghats region of Orissa, South Bombay, Malabar and parts of Assam. The lateritic soil is of a type peculiar to tropical regions, and is commonly formed from the atmospheric weathering of various rock formations under monsoon conditions of



INDIA
SHOWING
GENERAL DISTRIBUTION OF SOILS
Scale
AFGHANISTAN
JAMMU & KASHMIR
PAKISTAN (WEST)
RAJASTHAN
NEPAL
BHUTAN
ASSAM
MANIPUR
PAKISTAN (EAST)
BURMA
UTTAR PRADESH
VINDHYA PRADESH
BIHAR
BHOPAL
MADHYA BHARAT
MADHYA PRADESH
ORISSA
SAURASHTRA
DIU (Portuguese)
DAMAN (Portuguese)
HYDERABAD
BOMBAY
ANDHRA
MYSORE
Soil References -
Alluvial Soil
Coastal Sandy Alluvium
Old Alluvium (Red)
Saline and Deltaic Soil
Calcareous Soil
Deep Black Soil
Medium Black Soil
Mixed red & Black Soil
Red sandy Soil
Laterite Soil
Forest and Hill Soil
Gravelly Soil
Submontane Region
Terai Soil
Marshy land
Peat Soil
Desert Soil
Red loam
Major Climatic Regions -
Sikkim and Bhutan are attached to India by special treaty.

Fig. 15

alternating wet and dry seasons; it is characterized by high contents of hydrated oxides of aluminium and iron with small amounts of manganese, titanium and similar compounds in the upper layers. Inherently, these lateritic soils are of relatively low fertility and tend to be deficient in the common nutrients, including even potash. An interesting observation, however, is that in many areas these naturally poor lateritic soils are at present of greater agricultural importance than many of their richer and potentially more productive geographical neighbours, the black soils; this is due to the fact that the former are usually situated on higher land with fairly copious rainfall, whilst the latter occur at lower levels in areas of deficient rainfall.

"*Black Soils :* These extend over the greater part of the Bombay province, Kathiawar, Berar, the west part of the Central Provinces, Central India and Hyderabad, and some parts of the Madras Presidency. Intermediate between the main red and black soil groups, there are considerable areas of mixed red and black soils, e. g. in the south of Bombay, south-east Central Provinces, east central Bihar, southern Uttar Pradesh, etc. The black soils vary in depth from shallow (1 to 2 feet) to very deep (20 feet or over); in texture they vary from loam to clay and a characteristic feature is the development of pronounced cracks in the dry season, especially in the texturally heavy, deep types. A *kankar* or calcareous zone is usually to be found at some depth in most black soil profiles, whilst calcium carbonate in the uncombined state is commonly present throughout the soil. Although, like most soils in India, they tend to be deficient in nitrogen and organic matter, the black soils are potentially rich and productive, with lack of adequate rainfall being the principal limiting factor in crop production. Considerable care and skilful management are necessary, however, in their irrigation, particularly of the texturally heavier types.

"*Alluvial Soils :* Soils of alluvial origin form an ill-defined group, distributed mainly in north-western, northern and north-eastern parts of India. The alluvial soils cover large portions of Sind, the Punjab, Uttar Pradesh, Bihar and Bengal, as well as parts of Assam and Orissa. In addition, there are extensive deltaic areas throughout southern India. In many parts of the country it is possible to sub-divide these alluvial soils into two groups of recent alluvium and old alluvium, such as occur, for instance, on the north and south banks respectively of the Brahmaputra in Assam, but a detailed classification of alluvial soils would require elaborate study. Although the soils naturally are of high inherent produc-

tivity, their agricultural utilization under irrigation has been complicated by the problem of salinity. Saline areas occur not in well-defined or regular patches, but more or less scattered at random throughout large stretches of alluvial land especially in Uttar Pradesh, the Punjab and Sind. In the latter, for instance, one of the characteristic features of the alluvial soils, which occupy the major portion of the province, is their lack of uniformity, with marked variations occurring within very restricted area.

Other soil types: Various other distinct soil groups occur here and there throughout the country. In the western portion of Sind and in the north-west of the Punjab, for instance, extensive areas of calcareous soils are found. About one-seventh of the total land surface of India is under forest, and forest and hill soils form a group of major importance. The principal factor of difference in the formation of the forest soil, as contrasted with the agricultured soil, is associated with the characteristic deposition of organic matter from forest growth. This organic matter may give rise either to acid humus, resulting in soils of low base status, or to neutral or slightly acid humus, favouring the formation of soils of higher base status. Desert soils occupy large areas, under arid and semi-arid conditions, notably in eastern Sind, southern Punjab and Rajputana. The Rajputana desert alone covers an area of about 40,000 square miles, and the soils consist mostly of sands, often with high soluble salt contents, high pH values, low organic matter contents and varying amounts of calcium carbonate. Peaty and marshy soils where drainage is naturally a prerequisite of successful reclamation occur to a limited extent in certain parts of India, e. g. in Travancore-Cochin. The *Kasch* soils of Chittagong could probably also be classed in this group. There are relatively limited areas of the so-called Terai soils, occurring in sub-montane regions between the Bhabar, or area just below the hills, and the plains."

Nutrient requirements of Indian soils

Stewart (1947) concludes that the chief value of the results of past work lies not so much in providing for extension staffs a ready basis of sound information for direct translation into farming practice under specific soil and climatic conditions, but rather in serving as a guide to future experimental work. With these reservations, however, it is still possible to draw general conclusions regarding the nutrient requirements of Indian soils.

Nitrogen deficiency is very widespread and it is necessary to take every possible step to ensure the return to the soil of anything likely to improve its

nitrogen status. The factor of apparent prime importance to crop yield is the application of nitrogen in some form which will become available to the plant reasonably quickly. Although priority should obviously be given to manures available locally, Stewart suggests that consideration might also be given to concentrated forms of the nutrient.

Present indications are that the need for phosphate, especially in combination with nitrogen, may be greater than is commonly supposed. In the present context, we should stress the importance of phosphate to legumes, not only in improving their yield and feeding quality, but also in improving soil fertility. Potash may be necessary at the higher levels of nitrogen and phosphate nutrition in many Indian soils.

Stewart states that the regular use of such bulky organic supplements as farmyard manure can do much to increase the productivity of a soil over a number of years. As a source of nitrogen, farmyard manure is considerably slower in its action and less effective than equivalent amounts of nitrogen in readily available concentrated forms. Response to fertilizers in certain soils may be enhanced if they are used to supplement basal dressings of bulky organic manures. The manurial value of organic manures in the season of their application depends on the degree of decomposition, moisture content and other properties of the supplement, as well as on the moisture and nitrogen status of the soil. "Whilst it is of the greatest importance not to under-estimate the virtues of humus, it is equally important neither to over-state the case for organic manures nor to minimise the value of mineral supplements ; both have their uses." Fertilizers can, for example, be used to produce humus, as in the phosphatic manuring of legumes or the manuring of green manure crops.

Effect of Fertilizers on Yield and Quality of Grasses and Legumes

Bearing in mind Stewart's advice (1947) not to place too much reliance on the results of earlier experimental work in India, we will now give some results of studies on the effects of manures and fertilizers on grasses and legumes grown for fodder. Much of this discussion is based on the review by Sen (1953).

Bal and Anthawala (1935) laid out two sets of quadruplicate plots in a Latin square design and applied different types of fertilizers (see Table LXXXII); the soil was fairly rich in calcium and phosphorus. Superphosphate has a slight effect on the phosphorus content of the herbage, probably because this effect is marked

by increased growth and consequently a higher yield of dry matter. The mineral composition of grass manured with ammonium sulphate plus superphosphate is about the same as from the unmanured plots, but the total yield of dry matter and hence of mineral per acre is much increased. With ammonium sulphate alone the yield of dry matter per acre is appreciably increased but the mineral composition is only slightly affected. Manuring of a soil with an element in which it is deficient has a favourable effect (Table LXXXIII), e. g. the effect of manuring with Ca and P on the composition of plants grown on soils poor in these nutrients. Similar results have been obtained in a more recent experiment conducted at Jubbulpore (Bal, 1939-40). The effects of manuring on crop composition are further shown in Tables LXXXIV and LXXXV. Table LXXXIV (Ramiah, 1940-41) shows that nitrogenous fertilizers (especially ammonium sulphate) tend to increase the crude protein contents of certain grasses; calcium content shows little variation (Tables LXXXIV and LXXXV); the adequate phosphorus status of the Sabour soils (Bihar) may explain why the phosphorus content of the crop is but little affected (Anwar Ullah, 1939-40).

The favourable effect of applications of ammonium sulphate on the nitrogen content of *kolukattai* grass (*Cenchrus ciliaris*) and Rhodes grass (*Chloris gayana*) is confirmed by Ramiah (1940-41). At Dacca, the application of fertilizers containing (*a*) nitrogen alone, and (*b*) nitrogen plus minerals to pasture plots resulted in a general increase in yield of dry matter and protein content (Chatterjee, 1936-37). The yield and nitrogen content of maize fodder grown on plots receiving certain organic and inorganic forms of nitrogen are higher than from the control plots, manures containing ammonium sulphate giving the highest yield (Mukerji and Aggarwal, 1942).

At Sabour, the nitrogen content of berseem (Table LXXXV) is little affected by fertilizers, probably because of good nodulation. Ramiah (1938-39) notes little difference in the content of nitrogen and its distribution between samples of lucerne grown in cattle-manured and control plots at Coimbatore.

Parr and Bose (1944, 1945) find that manuring with superphosphate not only increases the yields of berseem, but also raises its phosphorus content by 200 to 300 per cent. Cowpeas grown in the same plot after the berseem not only give a higher yield but the phosphorus content of the plants from the superphosphate plots is much higher than from the no-manure control plots. Later

Table LXXXII

Effect of fertilizers on the composition of herbage ; Telankheri Farm, Nagpur

(Average of 3 years for grass cut at monthly intervals, at flowering and at ripe stage)

Treatment of soil	Yield of nutrients per acre (lb.)				Percentage composition of grass (on dry basis)			Percentage composition of the soil of the locality
	Dry matter	Silica-free ash	CaO	P_2O_5	Silica-free ash	CaO	P_2O_5	
Control	2902	112.2	22.8	11.8	4.11	0.84	0.45	Total P_2O_5 - 0.06
200 lb. super-phosphate/ acre/annum	2903	133.8	26.6	13.3	4.62	0.94	0.48	Available P_2O_5 - 0.008 Total CaO - 1.82
do. plus 100 lb. Ammonium sulphate/ acre/annum	4138	164.6	29.7	16.6	4.15	0.77	0.44	Available K_2O - 0.04
100 lb. Ammonium sulphate/acre/annum	3830	155.2	27.8	15.8	4.24	0.76	0.45	Total N - 0.05

Table LXXXIII

Effect of fertilizer treatment on the mineral composition of grasses ; Adhartal Farm, Jubbulpore

(Average of 3 years)

Manurial treatment	Percentage composition of grasses on dry matter basis								Composition of the soil of the locality
	Grass cut in the 1st fortnight of October		Grass cut in the 2nd fortnight of October		Grass cut in the 1st fortnight of November		Grass cut in the 2nd fortnight of November		
	P_2O_5	CaO	P_2O_5	CaO	P_2O_5	CaO	P_2O_5	CaO	
Untreated	0.206	0.490	0.156	0.501	0.142	0.571	0.126	0.621	Total P_2O_5 - 0.02
Initial application of 20 mds. bone-meal per acre	0.390	0.527	0.396	0.526	0.290	0.562	0.261	0.642	Total CaO - 0.43
Initial application of 30 mds. slaked lime per acre	0.200	0.535	0.163	0.547	0.193	0.618	0.122	0.635	
Initial application of 30 mds. basic slag per acre	0.438	0.611	0.388	0.623	0.263	0.620	0.279	0.711	

TABLE LXXXIV

Effect of manures on the composition of Rhodes and Kolukattai grasses
(Average of samples at flowering stage from two series of plots in each case)
Percentage composition on dry matter basis

Constituents	Control	Cattle manures (200 lb. N/acre)	Ammonium sulphate (200 lb. N/acre)
Rhodes Grass			
Soluble ash	6.64	7.13	7.50
Crude protein	10.01	11.15	14.30
CaO	0.73	0.79	0.83
P_2O_5	0.27	0.48	0.32
Kolukattai Grass			
Soluble ash	9.05	9.22	9.20
Crude protein	7.52	9.12	12.18
CaO	1.06	0.96	0.90
P_2O_5	0.28	0.47	0.29

studies showed that the recovery of phosphate added as manure is apparent not only in berseem itself but also in the crops grown on the phosphate plots after berseem. The indifferent growth of berseem in provinces other than the Punjab is probably due to the lower phosphorus content of soils elsewhere. The efficiency of phosphorus utilization by berseem may be increased in the presence of adequate potash.

TABLE LXXXV

Effect of manures on the composition of berseem

(Average of several cuts)

Nutrients supplied from manure	Percentage composition of crop (on dry matter basis)					Percentage composition of soil
	Soluble ash	Crude protein	CaO	P_2O_5	K_2O	
Untreated	12.21	20.50	2.65	1.14	3.61	Available P_2O_5 0.066
Nitrogen	14.03	22.51	2.56	1.16	3.60	Available K_2O 0.013
Phosphorus	11.99	18.80	2.72	1.18	3.60	CaO 0.216
Calcium	13.25	19.38	2.78	1.22	3.53	Total nitrogen 0.079
Nitrogen & phosphorus	13.03	23.55	2.76	1.14	3.56	
Nitrogen & calcium	12.98	23.48	2.63	1.14	3.78	
Phosphorus & calcium	13.23	21.36	2.60	1.19	3.63	
Nitrogen & phosphorus and calcium	11.95	21.65	2.62	1.12	3.41	

We have already noted in Table XII that berseem is relatively high in cobalt and copper as compared with other important Indian grasses and forage crops. It is known that this legume responds well to phosphatic fertilizers, giving higher yields of nutritious fodder, rich in protein, phosphorus and calcium. A study is in progress in the Indian Agricultural Research Institute on the effect of different forms of phosphatic fertilizers on the uptake of cobalt and copper by berseem. The different forms of phosphate each applied at the rate of 80 lb. P_2O_5 per acre were Rehohyper, Ammophos bonemeal, ground Trichy nodules, bone super, triple superphosphate, rock phosphate, bone meal compost, Agrophos and Selectophos. The analytical results show increased uptake of cobalt and copper over the control with the different fertilizer treatments ; the absorption is most pronounced with Ammophos, bone meal and bone super. The cobalt and copper

contents of the crops decrease slightly under the treatments with successive cuttings.

Example of mineral imbalance

Surveys of the chemical composition of pastures were made by the Government Agricultural Chemist, Madras, in a scheme financed by the Indian Council of Agricultural Research from 1935 to 1942 (Government of India, 1953). Herbage from pastures collected from different parts of the State was analyzed for mineral content, chiefly CaO and P_2O_5. The results show that (a) the entire district of Cuddapah, south-western portion of Anantapur, north-east portion of Chittoor, the northern one-fourth of Madura district, the whole of Nilgiris, more than half of Malabar along the coast line, and the whole of South Canara district are poor in CaO, i.e. below 0.6 per cent ; the rest contain more than this limit ; (b) the entire district of Guntur, the whole of Cuddapah, north-eastern half of Kurnool, nearly the northern half of the Anantapur district, northern extremities of Bellary, the north-east and north-west portions of Chittoor, the southern half of Nellore, northern one-third of Madura, the north-west corner of Coimbatore, the whole of Nilgiris and South Canara and half of the Malabar district along the coastline are poor in P_2O_5, i.e. below 0.4 per cent. The P_2O_5 content of the rest is above this limit.

The same survey showed that the cattle in the Kurnool district and adjoining tracts of Nellore suffer from fluorosis. The symptoms are impairment of gait, teeth affection, over-grown hoof in young animals and bone exostosis in advanced cases with attendant loss of condition. The disease is due to the presence of fluorine in the drinking water in excess of 1.0 p.p.m. Fluorine is derived from parent rocks and soils of the area, which provide a permanent source of supply of fluorine to the water which flows through them. Soils produced by the weathering of such rocks are also rich in fluorine, two particular samples containing 310 and 410 p.p.m. respectively. Table LXXXVI shows that certain feeds and fodders are also rich in fluorine.

Table LXXXVI

Feeds and fodders rich in fluorine

Feed	Village	Fluorine in mg. per grm. of ash
Mixture of cholam straw, ragi straw and ground-nut manures	Gospad (Sirval taluk) Bhimunipad (Koilkuntla) Singanapalle	0.0818 0.0719 0.2604

Therefore, the fluorine content of the water and the feeds, and other conditions such as the local climates are responsible for the spread of the disease. As their thirst increases in summer, the animals drink more water and with it fine rock particles which contain fluorine. In addition, the imbalance of minerals, the supply of CaO and P_2O_5 and the deficiency in P_2O_5 aggravate the disease considerably.

Fluorosis is present in human beings in the Nellore district but the cattle seem to be free from it, probably because of the well-balanced nature of the pastures found in this tract.

Fertilizer experiments on grassland

Zende and Kundalkar (1954) carried out preliminary trials on the manuring of natural grassland from 1946 to 1949 at the Government Dry Stock Farm at Palghar (District Thana), on the Western Railway about 50 miles north of Bombay. The area in question is a narrow strip of land from 5 to 10 miles wide along the sea coast ; there are extensive grasslands, of which 5,000 acres are attached to the Farm. The soil is an ash-grey clay loam varying in depth from eight to ten inches to several feet. The lime reserve is very low at the surface and the pH value varies from 6.5 to 7.5.

Most of the average annual rainfall of about 70 inches is received during July and August. The grass is usually harvested between October and December when at the maximum height of about five to six feet.

The four major species are : *ber* (*Ischaemum aristatum*), *moshi* (*Iseilema wightii*), *phul* (*Themeda cymbaria*), and *rohida* (*Eulalia argentea*).

The objective was to discover the best dose and form of nitrogen in combination with phosphoric acid ; the treatments were as follows :

(1) No manure.

(2) Farmyard manure supplying 30 lb. nitrogen per acre.

(3) Groundnut cake supplying 30 lb. nitrogen per acre.

(4) Farmyard manure plus sulphate of ammonia each supplying 15 lb. nitrogen per acre.

(5) Groundnut cake plus sulphate of ammonia each supplying 15 lb. nitrogen per acre.

(6) Farmyard manure supplying 60 lb. nitrogen per acre.

(7) Groundnut cake supplying 60 lb. nitrogen per acre.

(8) Farmyard manure plus sulphate of ammonia each supplying 30 lb. nitrogen per acre.

(9) Groundnut cake plus sulphate of ammonia each supplying 30 lb. nitrogen per acre.

(10) Superphosphate (supplying 40 lb. P_2O_5 per acre), alone and in combination with nitrogen.

Rainfall is shown in Table LXXXVII. In 1946 it was well-distributed and the grass yields were high. In 1948, the cyclonic rains washed away the harvested produce and no results could be recorded ; the cyclone also affected the 1949 results, so that only the data obtained in 1946 and 1947 could be used.

TABLE LXXXVII

Rainfall at Palghar, Bombay

(Inches)

Month and Year	May	June	July	August	September	October	November	December	Total
1946	0.32	15.71	19.23	9.99	4.56	0.20	2.36	0.03	52.40
1947	-nil-	2.17	24.09	28.72	19.16	1.33	-nil-	-nil-	75.47
1948	-nil-	15.17	23.85	10.69	8.98	0.27	8.07	-nil-	67.61
1949	-nil-	13.34	32.34	16.07	37.66	3.96	-nil-	-nil-	103.37

Table LXXXVIII gives a summary of results for these two years separately and together; they have been statistically analysed by the Indian Council of Agricultural Research. Table LXXXIX gives the response of the natural grass to phosphate and to the different forms of nitrogen employed, alone and in combination. At a level of 70 lb. N given in a combination of farmyard manure and sulphate of ammonia, the highest increase in yield of 44 per cent over the no-manure plot is obtained. The superiority of this combination is also seen at the 60 lb. N level, when this increase is about 52 per cent ; the extra yield is, however, not economical. The best manurial treatment for these particular grasslands would be to add 30 lb. of N supplied by 15 lb. each of farmyard manure and sulphate of ammonia, along with 40 lb. P_2O_5 as superphosphate. This treatment will yield 3.32 tons of air-dried grass per acre, an increase or 1.02 tons of 44 per cent over the no-manure plot.

TABLE LXXXVIII

Results of fertilizer experiments at Palghar

(Tons per acre)

	1946				1947				1946-47			
	No P_2O_5	P_2O_5	Mean	S. E.	No P_2O_5	P_2O_5	Mean	S. E.	No P_2O_5	P_2O_5	Mean	S. E.
No nitrogen	2.60	2.76	2.68		1.99	2.17	2.08		2.30	2.47	2.39	
30 lb. N												
Farmyard manure	2.88	3.33	3.10		2.58	2.67	2.63		2.73	3.00	2.87	
Groundnut cake	1.93	3.49	2.71		1.88	2.58	2.23		1.91	3.04	2.48	
Farmyard manure/sulphate of ammonia	2.84	3.81	3.32		2.69	2.83	2.76		2.77	3.32	3.05	
Groundnut cake/sulphate of ammonia	2.12	3.38	2.75	0.132	1.96	2.55	2.26	0.095	2.05	2.97	51	0.097
60 lb. N												
Farmyard manure	3.42	3.59	3.50		2.66	2.90	2.78		3.04	3.25	3.15	
Groundnut cake	3.17	3.81	3.49		2.82	3.02	2.92		3.00	3.42	3.21	
Farmyard manure/sulphate of ammonia	3.54	4.19	3.86		2.74	2.77	2.76		3.15	3.49	3.32	
Groundnut cake/sulphate of ammonia	2.57	3.72	3.14		2.15	2.92	2.54		2.37	3.32	2.85	
Mean	2.79	3.57	3.12		2.39	2.71	2.55		2.59	3.14	2.86	
S. E.	0.071				0.060				0.046			

TABLE LXXXIX

Yield and response to N and P_2O_5 singly and in combination (Palghar)

(Tons per acre)

Form of Nitrogen	No P_2O_5	40 lb. P_2O_5	Response to nitrogen alone in absence of P_2O_5	Response to N over P_2O_5	Response to P_2O_5 over N
			Percentage increase of Col. 1 over no-manure	Percentage increase of Col.2 over 40 lb. P_2O_5 alone	Percentage increase of Col. 2 over Col. 1
Farmyard manure	2.885	3.125	25.4	26.5	8.3
Groundnut cake	2.455	3.230	6.7	30.8	31.6
Farmyard manure plus sulphate of ammonia	2.960	3.405	28.7	37.9	15.0
Groundnut cake plus sulphate of ammonia	2.210	3.145	3.9	27.3	42.3
S. E. for sub-plot treatments within a main-plot treatment	0.098				
S. E. for main-plot treatments within a sub-plot treatment	0.097				
No Nitrogen (control)	2.299	2.466			

There are no legumes in this grassland association, and none appeared as a result of treatments. The grass association itself is rather characteristic of this particular part of India, but the results cannot apply directly in other parts of the country. Further experimentation is necessary in each of the main grassland regions tentatively outlined in Chapter VI.

Composite samples of the grasses were analysed for protein, calcium and phosphorus content, to study the effect of manurial treatment on nutritive value (Table XC). It is concluded that the same doses as recommended for optimal yields (30 lb. N plus 40 lb. P_2O_5) give the best results as regards quantity and quality of grass ; the yield increases from 2.30 to 3.32 tons, the protein per acre from 128 to 235 lb., the lime per acre from 19.6 to 35.4 lb. and the phosphoric acid from 3.6 to 8.9 lb. The protein, lime and phosphoric acid contents of the grasses increase to the extent of 27, 25 and 74 per cent repsectively.

TABLE XC

Chemical analysis of grass (Palghar)

(Per cent)

Form of nitrogen	Crude protein	Lime	Phosphoric acid	Lime : phosphoric acid ratio
No nitrogen	2.49	0.380	0.069	5.5
do plus Super	2.53	0.504	0.152	3.3
50 lb. N				
Farmyard manure	2.58	0.336	0.072	4.7
do plus Super	2.67	0.448	0.153	2.9
Farmyard manure and sulphate of ammonia	3.13	0.352	0.071	5.0
do plus Super	3.16	0.476	0.120	3.7
Groundnut cake and sulphate of ammonia	2.66	0.308	0.068	4.5
do plus Super	3.07	0.420	0.153	2.7
60 lb. N				
Farmyard manure	2.97	0.308	0.072	4.3
do plus Super	3.16	0.420	0.138	2.7
Groundnut cake	2.97	0.336	0.073	4.6
do plus Super	2.94	0.448	0.153	2.9
Farmyard manure and sulphate of ammonia	3.11	0.308	0.091	3.4
do plus Super	3.20	0.420	0.153	2.7
Groundnut cake and sulphate of ammonia	3.07	0.336	0.073	4.5
do plus Super	3.11	0.448	0.126	3.5

With regard to trials being initiated at Pashulok by the Animal Husbandry Department of the Government of Uttar Pradesh, in association with experts of F.A.O., Dr R.R. Aggarwal, Agricultural Chemist to Uttar Pradesh Government, has recommended certain fertilizer treatments for these soils of the Terai type. It is suggested that an application of ammonium sulphate (10 lb. N per acre) and superphosphate (20 lb. P_2O_5 per acre) should be made. The two major nutrients deficient in the soils of Uttar Pradesh are again nitrogen and phosphorus. Terai soils are usually richer in nitrogen and more deficient in phosphorus than soils further south in Uttar Pradesh. Liming may be necessary at Pashulok in

connection with the establishment of pastures and fodder grasses to feed the sheep flock established there.

Certain observational trials on the effect of application of fertilizers on natural grassland have been made in the experimental plots of the Damodar Valley Corporation. Although no accurate data are available, these trials seem to indicate that fertilizers accelerate the ecological progression from inferior to superior types of grassland.

Cropping systems and soil fertility

There is at present little likelihood that a pasture legume similar to the white clover of humid temperate lands and which actually flourishes under grazing conditions will be found for incorporation in the natural grasslands of India or even in special seed mixtures for artificial reseeding. The chief contribution of legumes to soil fertility will, therefore, be from the crops grown on arable land primarily for grain, and the crops grown as fodder and green manure.

In this connection, reference should be made to the studies of the possibilities of introducing mixed farming which have been made at the Indian Agricultural Research Institute, Anand, Uttar Pradesh and elsewhere. The work of Mukherjee, Mandal and others at the Agricultural Research Institute, Sabour, Bihar, is also relevant. These workers have investigated the effects on soil fertility of various cropping systems incorporating grasses, legumes and grass/legume mixtures. It has been noted that the inclusion in rotations of the legumes which are commonly grown in Indian agriculture may not always help the soil to maintain a correct nitrogen economy. It is essential to choose the correct type of legumes. Although *kalai* (*Phaseolus mungo*) is not extensively grown in Bihar, it has a much greater effect on soil nitrogen status than the common legume of the State, gram, and the other legumes, soybean, *guar* and peas.

The inclusion in rotations of grass/legume leys or other forms of resting breaks is, of course, very difficult to achieve when the demand for food grains for direct human consumption is so great. But there is no doubt that the fertility of Indian soils is generally deteriorating, and that yields of crops on many soil types cannot be raised to a satisfactory level by fertilizers alone. Studies at Sabour have shown that the physical condition of these soils has greatly deteriorated due to continuous grain farming, with two crops per year. Mandal and his associates have, therefore, attempted to evolve rotations in crop cycles of 4 or 5 years which will lead to a

regeneration of the fertility lost in grain farming (Mandal and Mukerjee, 1953 a and b; Mandal and Chatterjee, 1953; Chatterjee, Mandal and Alam, 1954; Mandal, 1955).

Mandal (1955) discusses the effect of various systems of cropping and different species of grasses and legumes on soil nitrification and the formation of aggregates.

TABLE XCI

Yield of maize and nitrogen and aggregate status of Sabour soil as a result of growing grasses and legumes in the previous season (Mandal, 1955)

Previous cropping system	Yield of maize (grain in mds. per acre)	Percentage of water stable aggregates greater than 0.25 mm.	Percentage of total nitrogen
Fallow	2.20	5.80	0.017
Doob grass alone	4.90	15.00	0.026
Doob grass/burr clover	6.10	26.30	0.041
Lucerne alone	2.10	7.00	0.024
Cenchrus ciliaris/lucerne	2.60	5.00	0.020
Pennisetum pedicellatum/senji	5.00	6.00	0.037
Flinder's grass/Lucerne	2.10	6.20	0.015

The beneficial effect of *Cynodon dactylon* on soil structure is particularly notable. Mandal and Mukerjee (1953 a) found that a fallow/wheat rotation plot had 30 per cent water stable aggregates as compared with 14.6 per cent on a maize/wheat plot. Much of the beneficial effect of monsoon fallowing is probably due to the luxuriant growth of a number of grasses during these months. The rate of regeneration of soil structure on arable soils at Sabour has been rapid, even after one-year leys.

The results of the work of Mandal and his associates may be summarised as follows :

Legumes vary in their effect on soil nitrogen ; for upland soils in Bihar *kalai* is an excellent crop in this respect. A mixture of *Cynodon dactylon* and burr clover (*Medicago tribuloides*) would provide a very good sward for the winter months at Sabour ; the inclusion in this mixture of black medic (*Medicago lupulina*) may extend the life of the pasture until the end of spring. Such a mixture has a good effect on soil nitrogen and the aggregation of soil particles.

Pennisetum pedicellatum from Nigeria is more drought resistant and gives higher yields than the common grasses (Elephant grass, Rhodes grass, Sudan grass, but has little effect on soil structure. Another mixture of probable value might be *Cenchrus ciliaris*/*Phaseolus mungo*/senji (*Melilotus parviflora*). *Cynodon dactylon* has a much greater effect on soil structure than the taller grasses, *Pennisetum pedicellatum*, *Pennisetum purpureum*, *Chloris gayana* and *Cenchrus ciliaris*.

In the following section we give some examples taken more or less at random of the use of legumes in cropping systems. Their effect on soil fertility will depend primarily on the stage of maturity at which they are harvested, and the way in which this harvesting is done. It is probable that, under most conditions in India, the harvesting of a legume for feeding green or for conservation as hay or silage will, provided phosphatic applications have been given, have a greater effect on the yield of subsequent crops than its harvesting for mature grain. It is perhaps not to be expected that there will, under present conditions, be any great increase in the area of cultivated land devoted to the production of leguminous fodder crops.

The chief interest in India is, therefore, in the practice of green manuring, to supplement the organic fertility provided by farmyard manure (of which about 40 per cent is available for manurial purposes) and oilcakes (of which about one-third is used as organic manure) (Panikkar, 1952). Although the practice of green manuring is tending to go out in other countries, particularly where a cash crop can be grown at the same season, it still offers one of the cheapest and best sources of organic manure within the reach of Indian farmers.

Panikkar states that green manuring is adopted invariably in all the rice tracts of the country, also for wheat in Bombay, Madhya Pradesh, the Punjab and Uttar Pradesh ; for millets in Bombay and Madras ; and for oats, sugarcane, cotton, jute, vegetables and plantation crops in the States in which these are grown.

Many species of plants, herbs, shrubs and trees, both leguminous and non-leguminous, are used. Herbaceous annuals or perennials may be actually grown in the field and ploughed in, or they may be grown elsewhere and brought in for the purpose. Special quick-growing trees and shrubs may be grown on field bunds or waste lands to provide green matter for manure.

It would be desirable to develop dual-purpose types of legumes, suitable either as green manure or as fodder depending on the season and the farmer's cropping system in any given year.

Cropping systems for wheat

Examples of typical wheat rotations in most parts of India collected by I.C.A.R. are given in Table XCII. In this connection, a new rotation at the Indian Agricultural Research Institute may be mentioned in passing.

Wheat is sown in October/November on irrigated land, and Hubam sweet clover is broadcast among the drilled rows of wheat. The grain crop is taken in the first week of April, a cut of sweet clover for fodder at the end of April, and a crop of sweet clover for green manure is ready for ploughing under at the end of May or early June.

Table XCII

Typical rotations with wheat in different States

Provinces and States	Region	Rotations
Baroda	Mehesana	As a second crop after *bajri* in the rotation—*bajri*/cotton or *bajri*/castor
	Amreli	In 60 per cent of the area : rain fallow and wheat followed by *bajri*, groundnut or *juar* in the second year
		In 40 per cent of the area : as a second crop after *bajri* or groundnut
		In unirrigated area : rain fallow and wheat. The wheat comes in once after 3 years after *juar* , cotton or *bajri* in the *kharif*
	Baroda	Monsoon-paddy, *bajri* or fallow
	Navasari	Paddy or fallow

TABLE XCII—*Contd.*

Typical rotations with wheat in different States.

Provinces and States	Region	Rotations
Bengal	—	1. *Rabi* legume/fallow/wheat 2. *Rabi* legume/*Aus* paddy/wheat The former system results in higher yield
Bihar	Patna Division	Irrigated : Paddy/wheat Unirrigated : Maize/wheat or wheat and gram Fallow/wheat or wheat and gram
	Tirhat Division	Unirrigated : Fallow/wheat Maize/*arhar* Fallow/wheat or cash crop
	Chota Nagpur Division	Irrigated : Early paddy/wheat Maize or *urid*/wheat
	Bhagalpur Division	Unirrigated : Fallow/wheat Very early paddy or *marua*/wheat Maize/wheat
Bombay	Gujerat	Unirrigated : Cotton or *juar* in *kharif*/ wheat in *rabi* Maize/wheat Continuous wheat in irrigated and unirrigated land
	Deccan	Unirrigated : Wheat after wheat or *bajri*/ wheat Irrigated : Cotton or *juar*/wheat Linseed/gram and wheat
	Karnatak	Wheat after wheat. Irrigated Unirrigated : Cotton or *juar*/wheat
Madhya Pradesh	...	Unirrigated : Wheat after wheat on heavy alluvial and fertile soils Wheat for one or two years followed by gram, *massoor*, *teora*, peas and linseed Mixture of wheat and gram year after year Mixture of linseed, *teora* and wheat, or wheat, gram and *teora* year after year

TABLE XCII—*Contd.*

Typical rotations with wheat in different States

Provinces and States	Region	Rotation
Gwalior	Gwalior	Irrigated : Sugarcane, sunnhemp in the *kharif*, wheat in the *rabi* Unirrigated : Wheat after wheat
	Malwa	Irrigated : Cotton/wheat In the Bhilsa dist. wheat after wheat for a number of years
Hyderabad Deccan	Marethwada	Unirrigated : (*i*) Cotton and *juar* in the cotton district (*ii*) Linseed and gram along the Godawari valley
	Karnatak	Unirrigated do.
Jammu and Kashmir	Jammu	Kandi (rain-fed tracts) (*i*) Wheat/mixture of *moth* and *bajri*/wheat (*ii*) Wheat/maize and *senji*/sugarcane (Canal areas)
	Kashmir	(*i*) Wheat/maize/wheat (*ii*) Wheat/*mung*/*mash*/wheat
Madras	Coimbatore	Irrigated Grown mainly as a mixture with cotton in black soils
	Cuddapah	*Ragi* or red *cholam*/wheat/groundnut or *korra*/wheat
	Madura	(*i*) Garlic/wheat/beans, potatoes or *sanai* for the first crop (*ii*) Wheat/*ragi* for the second crop
	Bellary	Unirrigated : Wheat after wheat Irrigated : *Mungari cholam* or *korra*) wheat or chilli/wheat
	Nilgiris	(*i*) Potato/wheat or any other cereal like *samai*, *ragi* (*ii*) Barley/potato

TABLE XCII—*Contd.*

Typical rotations with wheat in different States

Provinces and States	Region	Rotations
Madras	Anantapur	Irrigated : *Ragi*/wheat and *korra*
	Kurnool	Wheat generally follows *cholam*, cotton or groundnut
Uttar Pradesh	Upper hills	Unirrigated : (*i*) Wheat/*marua*/coarse paddy (*ii*) Wheat/*marua*/potato Wheat/paddy/potato
	Lower hills	Sugarcane/fallow/wheat/paddy/gram G. M./wheat/early paddy/maize/peas
	Terai	Early paddy/wheat Late paddy/pea fodder/fallow/wheat
	Plains (Western)	Sugarcane/fallow/wheat/cotton Fallow/wheat/*juar*/gram
	Plains (Central)	*Juar* and *arhar*/fallow/wheat, Sunnhemp/wheat/cotton or *juar*
	Plains (Eastern)	*Juar* and *arhar*/fallow/wheat/sugarcane Paddy/peas/G.M./wheat
	Jhansi	Fallow/wheat *Juar*/*arhar*/fallow/wheat *Juar*/gram/fallow/wheat
Punjab	Rawalpindi	Wheat/*toria*/cotton Maize/*senji*/sugarcane/wheat Wheat/cotton
	Hansi (Hissar, Rohtak, Gurgaon)	Wheat/durra/cotton Wheat/fallow/cotton Wheat/cotton/sugarcane Wheat/cotton Wheat/*guar*/fallow/fallow Wheat/sugarcane
	Lyallpur and Jhang	Wheat after wheat, cotton or sugarcane

TABLE XCII—*Contd.*

Typical rotations with wheat in different States

Provinces and States	Region	Rotations
Punjab	Ambala	Irrigated : Wheat/maize/sugarcane Wheat/maize/sugarcane (Ratoon) Unirrigated : Wheat/fallow/fallow/sugarcane Wheat/sunnhemp/green manure/sugarcane Wheat/maize/sugarcane
	Karnal	Wheat is generally sown after fallow or on lands in which the moisture is conserved during rains
	Simla	Wheat/maize/wheat Wheat/fallow/wheat Potato/wheat/maize

CROPPING SYSTEMS FOR POTATOES

The potato is grown as *rabi* crop from September/October to February/March over the greater part of the North Indian plains. Except where land has in special cases to be kept fallow, e. g. on heavy soil subject to flooding during the monsoon, *kharif* cropping is both possible and desirable for increasing economic returns, controlling weeds and conserving the soil. On well-drained sandy loam or loamy soils, potatoes may be rotated with green-manure legumes, fodder crops, grain crops and pulses.

Legumes for green manure are particularly desirable in light sandy soils deficient in humus and nitrogen and liable to erosion. *Crotalaria juncea* and *Cyamopsis psoralioides* are suitable for light sandy soils, and *Sesbania aculeata* for heavy soils. Green manuring has been practised as a routine measure on the light sandy soils of the Central Potato Research Institute. Good crops of sunnhemp were grown during recent *kharif* seasons and ploughed under with good effect on the tilth and fertility of the soil. Research is in progress on the comparative importance of green manuring as compared with fallows and the removal of green top-growth as fodder, and on the after-effect of phosphatic manuring of the green manure crop on the yield of the potato. It is not economic to grow green-manure legumes for the

whole potato acreage ; rotations with fodder and grain crops are followed, combined with adequate fertilization.

The best leguminous fodder crops in rotation with potato are cowpeas (*Vigna sinensis*), *guar* (*Cyamopsis psoralioides*) and *urid* (*Phaseolus mungo*) ; mixtures of maize and cowpeas, or sorghum and *guar* may also be grown. The fodder crop must be heavily manured with dung or farmyard manure, to increase fodder production and produce a residual effect on the potatoes. The fodder crop must be harvested early, by the end of August at the latest, to give sufficient time for the cultivation preliminary to the planting of the potatoes.

Grain crops such as maize, sorghum and paddy are not desirable as crops to precede potatoes because they exhaust the soil and leave little time for preliminary cultivation and planting of the potato crop. Economic considerations may, however, make their sowing essential, in which case adequate manuring, an assured water supply and early-maturing varieties are required. The soil should also be inherently rich. On large holdings, the difficulties with such soil-exhausting crops may be overcome by adopting two-year, three-year and longer rotations. In certain parts of Bihar, summer crops such as *cheena* (*Panicum miliaceum*) and *mung* (*Phaseolus radiatus*) may be grown after the potatoes have been lifted.

The Central Potato Research Institute is interested in groundnuts as a crop to precede potatoes. This legume gives good returns at small cost on light sandy soils, and the straw is very palatable to cattle. Early-maturing varieties are essential, and the rat menace has to be considered.

Near centres of population, where cultivation is intensive, potatoes are grown in rotation with vegetables such as chillies, onion, etc.

Typical one-year potato rotations

Kharif	*Rabi*	Summer
Fallow	Potatoes	
Green manure	Potatoes	
Maize (grain)	Potatoes	
Maize/cowpeas	Potatoes	
Guar or *urid*	Potatoes	
Groundnut	Potatoes	
Maize (grain)	Potatoes	
Maize (grain)	Potatoes (early)	*Mung* or *cheena*
	Potatoes (main crop)	*Mung* or *cheena*

Some growers inter-crop potatoes with wheat, castor, radish, onion, *sag*, etc. The seeds of wheat and castor are sown sparsely in furrows between two ridges ; the wheat is sown in widely spaced clumps. The intercrops mature after the potatoes have been lifted.

The fodder problem is less acute in hilly districts, and ample natural grass is available from the bunds of the terraces or in the forests. Potatces are usually grown after potatoes or are rotated with wheat, barley, peas and maize. It is normally possible to grow only one crop per year.

Cropping systems for oilseed crops

Groundnuts are grown generally as the only dry crop of the year. They are rotated with *ragi* in some districts; an early crop may be followed by horse-gram. Mustard is usually grown mixed with crops such as wheat, barley and gram Sesame is usually grown in rotation with horse gram, coriander, cotton, *ragi* and black gram. Linseed is grown in rotation with green gram, coriander, short-duration groundnuts and Bengal gram. Castor may be grown as a mixed crop with other *kharif* crops, or in rotation with *ragi*, groundnuts, cotton, tobacco and horse gram. The practice of growing oilseed crops mixed with or in rotation with some legumes is, therefore, already prevalent in India. Its extension on a systematic basis for increasing, for example, the production of leguminous fodder crops would, however, depend on the additional returns, if any, to be obtained by the cultivator.

Cropping systems for jute

The Jute Agricultural Research Institute has been working on double cropping within one year with jute and paddy. Encouraging results have also been obtained from growing a third crop of *khesari* (*Lathyrus sativus*), when the pulse seed is sown in standing paddy 1½ to 2 months before the paddy is harvested; this is not practised to any great extent in the jute-growing areas. The *khesari* has been recorded as yielding 6 to 10 maunds of grains and 9 to 15 maunds of dry fodder. This practice is thought to have great possibilities in maintaining the productivity of the land and providing good cattle fodder.

In 1952/53, investigations were made on the growing of legumes between the jute crop when this is cultivated in rows. The legume seeds are sown during the final inter-row cultivation, which is done usually two to two and a half months before the jute is harvested. The main interest is the possibility of using as green manure (a) the two to two and a half month-old leguminous crop, (b) the jute leaves

which fall during growth, and (c) the non-fibrous parts of the branches of the jute plant. It has been estimated that about 150 to 250 maunds of green matter are likely to be available for green-manuring purposes before the second crop of paddy or other winter crop. If successful, this method will eliminate the need for the regular *kharif* green-manure crop, which necessarily means the loss of one crop per season to the cultivators. In the jute-growing areas, paddy is the main food crop; although diversification of cropping by greater cultivation of leguminous crops for grain or fodder might be expected to be very advantageous, it would for this reason be difficult to replace paddy.

Cropping systems for coconuts

Most of the coconut acreage on the West Coast is in holdings of three to four acres in size. The inter-spaces between the trees are used by the ryots for the growing of food and other crops. The legumes are generally cow gram (*Vigna catjang*) and black and green gram (*Phaseolus mungo* and *Ph. aureus*). The cow gram can be grown partly for grain and partly as a green vegetable : it may be possible to consider using part of it as fodder. The black and green gram are grown only as pulse crops. Recently *kolinji* (*Tephrosia purpurea*) has been developed as a green manure ; this crop is unpalatable and it may be asked whether it might not be possible to replace it with a more dual-purpose crop.

Reclamation of alkaline land

There are large areas of cultivated and other land in some of the Indian States which have become alkaline, and have been abandoned for any use other than the provision of poor-quality grazing for low-grade livestock. It is, for example, estimated that there are some two to three million acres in Uttar Pradesh, of which perhaps one-half may be reclaimed for crop cultivation by the adoption of special measures. In this section we will consider only an example of how the existing grass cover on such land may be improved by proper management, and how legumes may be used in the process of reclaiming the less extreme types of alkaline land for crop production.

An experiment under the Silviculturist Uttar Pradesh, was commenced in July 1931 in Unnao District (Makhdoompur *Usar* Experiment) for the study of the improvement of grass in a typical *usar* area under varying conditions of fencing and protection, grazing and grass cutting. The results obtained at the conclusion of this experiment in 1939 (Raynor, 1939) were as follows :

(1) Grass production gradually improves for three or four years, both with partial and with complete closure to grazing.

(2) Thereafter, variations in grass yield appear to depend largely on the monsoon rainfall, good rains producing appreciably more than bad rains in both types of areas.

(3) After three years' complete or partial protection, the average grass yield over five years (three good monsoons and two bad), shows :

(a) for grazed areas (protected five months annually in monsoon) an increase from 2.75 to 11.1 maunds per acre dry grass=400 per cent increase.

(b) for completely protected areas, an increase from 2.75 to 13.7 maunds per acre=500 per cent increase. (The apparent difference between 11.1 and 13.7 does not allow for the quantity of grass grazed by the cattle from the open areas in seven months).

The difference between (a) and (b) scarcely justifies complete and continuous closure.

(4) The conclusion is that closure during the rains is adequate, and complete closure unnecessary.

Kanjilal (1945) gives the results obtained in the second Makhdoompur *Usar* Experiment (commenced 1939) from a comparison of the effects of periodic and rotational grazing on an improved *usar* area. Rotational grazing was adopted on one part of the area, and periodic grazing (controlled and uncontrolled) on the other. The dominant grass is *Sporobolus arabicus*, with *Chloris montana* and *C. barbata* next in abundance and co-dominant in years of good rainfall.

The results obtained under the experiment which was concluded in 1945 were as follows :

(*i*) Provided an area of this type is closed during the monsoon, the production of grass is unaffected by the incidence of grazing during the rest of the year. Controlling the incidence leads only to the better distribution of the grass crop produced during the monsoon.

(*ii*) Rotational grazing for one month followed by three months rest in rotation throughout the year, with an average incidence of one cattle unit per acre;

leads to a definite deterioration in grass production. This appears to be due partly to grazing during one month in the monsoon in each section and also partly to higher concentration of cattle in the open sections at short intervals, which aggravates destructive trampling as compared with a periodically grazed area with the same average incidence of grazing.

(*iii*) Periodic grazing for eight months with closure during the monsoon is, therefore, clearly to be preferred to rotational grazing for one month at a time, followed by three months rest, (i. e. for a total period of three months in the year) with the same average incidence.

Continued protection gradually improved the area and many colonies of valuable grasses such as *Iseilema laxum*, *Dichanthium annulatum* and *Cenchrus ciliaris* began to appear, indicating a general sweetening of the soil.

Bishan Mansingh (1954) agrees that protection is necessary, but also states from his own experience at Fatehpur, U. P., that vegetation will not thrive on alkaline lands unless measures are taken to collect rain water. All that is needed is to enclose the area in question with earth embankments on contour lines so as to hold as much water as possible. If *Crotalaria juncea* and *Sesbania aculeata* are sown and allowed to mature and wither on the enclosed plots and whatever remains is ploughed under in the following year, the soil condition is greatly improved and a good crop of indigenous grasses is obtained.

The *usar* land at Fatehpur, "deep layers of stiff, poorly aerated clays, devoid of all humus and containing salts in injurious amounts", is reclaimed for paddy cultivation as follows. During the break of the monsoon and during the winter rains when labour is readily available and the soil is soft, the land to be reclaimed is enclosed on four sides with earth embankments one foot high and two feet broad, leaving openings on the side through which silted water from the surrounding higher area may enter and collect in the enclosed area. This is then sub-divided into plots of convenient size along the contour lines.

On bad *usar* lands, salts are washed down in the first year by holding water in the treated area for about two weeks and then permitting it to escape. This practice is repeated as often as possible during the rainy season. If canal or tube-well water is available, *Sesbania aculeata* (*dhaincha*) is sown early in May and ploughed under about the first week of July when the legume is at the flowering stage. Paddy may be transplanted a fortnight later.

If water is not available, undecomposed compost or cattle manure mixed with some slaked lime is ploughed under soon after the first monsoon shower, 20 lb. per acre of sulphate of ammonia is applied during puddling operations, 20 lb. one month after the paddy has been transplanted.

There is no need to wash out the salts on mild alkaline lands; cultivation of paddy can begin in the first year.

Conservation of soil and water

This is one of the major problems of land use in India which requires a monograph to itself. The livestock population is one of the chief contributors to the sickness of Indian land expressed in seriously over-stocked grazing grounds, forest destruction, the characteristic appearance of the great and small rivers of India, and the floods which annually cause such great loss of life, property and crops. The main objective of this book is to present the problem of utilization of the grazing and fodder resources against a background of optimal conservation of soil and water. To support the studies of the ecological characteristics of India's grasslands and their correct management, data are urgently needed from experimental plots, to record soil loss and water run-off from good and degraded grassland associations. It is also desirable to study the effect of fodder legumes and other crops in field rotations on the capacity of cultivated land to conserve soil and moisture. Important results are already being obtained, for example at Sholapur in Bombay State, but much more requires to be done for the wide range of natural conditions and vegetation types to be found in India.

The Central Government has recently formed a special section of the Ministry of Food and Agriculture to deal with research, extension and education in soil conservation. Regional research, demonstration and training centres are being formed at :

Dehra Dun, with sub-centre at Chandigarh;
Kotah, with sub-centre in Kotar land of Gujerat;
Bellary (Mysore State);
Ootacamund (Nilgiri);

and the Desert Afforestation Research Station at Jodhpur.

The first four centres and sub-centres will carry out research on the problems of their respective districts, by collecting and analysing data on soils,

land use, rainfall, run-off, soil wash and the effectiveness of various types of vegetative cover in arresting soil erosion. They will also evolve methods for the control of erosion, reclamation of degraded land and the engineering aspects of gully control and terracing. Methods of land management for forests, pastures and cultivated crops will also be studied and suitable types of crop husbandry will be worked out.

CHAPTER XIV

PLANT BREEDING AND SEED SUPPLIES

THE extent to which research facilities and staffs should be devoted to the breeding of herbage and fodder plants should, of course, be governed by the potential demand for improved seeds of selected strains. Under the existing and probable future conditions in India, it does not appear that reseeding of natural pastures is likely to be undertaken on any large scale. Natural grazing grounds will probably be managed primarily on an ecological basis, using the facts of progression and regression obtained during the Grassland Survey to maintain an association at a desired level. This does not mean that no attention should be devoted to indigenous and exotic grasses and legumes for reseeding open grasslands or fenced pastures. The I. C. A. R. has approved the continuation of the breeding work on these plants at I. A. R. I. and Dharwar, described below. The chief demand may, however, be expected to be for short-term fodder plants, and particularly for legumes for incorporation into existing crop rotations on arable land. Here, however, the demand is primarily for grain legumes for human consumption and the breeding work at Kanpur and other centres is orientated in this direction. The importance of dual or triple-purpose legumes should be considered in this connection, namely, grain/forage, or grain/forage/green manure, so that the farmer can use the crop in one or the other direction depending on his seasonal needs or the current economic conditions.

Although little work has so far been done on short-season arable legumes, some of these crops have long been in common use among the farmers of North India (Mehta, 1954). The chief among these are *guar* (*Cyamopsis psoralioides*), cowpea (*Vigna catjang*), peas (*Pisum sativum* and *P. arvense*) and *metha* (*Trigonella foenum-graecum*). The first two are *kharif* crops, often grown mixed with gramineous fodder or grain crops, such as sorghum or maize. *Guar* is grown for cattle feed, both as green fodder and grain, whereas the cowpea yields pods and grains for human consumption and the leaves and stems as green fodder for cattle. Peas are grown largely for the grain for human consumption, although their use exclusively as green fodder is quite common. They are generally grown mixed with cereals when a grain harvest is contemplated, and

alone when grown for fodder. *Metha* is taken as a short-duration fodder legume after a late maturing *kharif* crop like cotton (which vacates the field in late November) has been harvested ; it is sown immediately after the cotton with the help of irrigation, in November/December, and is considered particularly suitable as a catch crop between a *kharif* crop and sugarcane, which is planted in February/March.

Recently, the Department of Agriculture of Uttar Pradesh has laid considerable emphasis on breeding short-duration *kharif* legumes, particularly *mung* (*Phaseolus aureus*) and cowpea, to replace the fallow preceding wheat, which is planted in the latter part of October and early November. The fallow has so far been considered essential to give the field not only time to recuperate its fertility but also to enable sufficient moisture from the rains to be retained in the soil to sustain the subsequent wheat crop. No legume variety which could seed before the end of the rainy season was available until the Department selected *mung* type 1, which seeds within two months of planting. The first picking of ripe pods, which yield about half the grain yield the crop is capable of giving, can be secured in 50 days from planting. This enables the farmer to gather sufficient seed for the next season's planting, with enough to sell or use for his consumption ; if no more pickings are taken, the rest of the crop can be used as green fodder or turned in as green manure a couple of weeks before the end of the rainy season. This has proved more effective than fallow in improving the soil fertility without depleting the reserves of moisture in the soil, adding about 20-25 lb. nitrogen per acre.

During the last five years in which the variety has been under distribution, several hundred villages have adopted it as a dual- or triple-purpose crop, especially in districts where land holdings are small and the extra labour involved in growing the crop and picking the pods is considered worth the immediate return in the form of seed or fodder yield ; this may not, however, attract the more prosperous farmers of larger holdings. Breeding of early maturing varieties of cowpeas, which are more prolific in fodder yields, is in progress.

A recent report from the Indian Agricultural Research Institute, New Delhi, records the promise given by mucuna or velvet bean, *Mucuna cochinchinensis* and *M. deeringiana* (1954). This is also a *kharif* legume, which yields more green fodder than the cowpea. However, the economic multiplication and distri-

bution of seed of *Mucuna*, which is a long-duration crop, are likely to be limiting factors in its competition with a popular short-duration crop like *mung* Type 1.

Experiments on legumes suitable as fodder are being conducted also at Sirsa (Punjab, India) by the Fodder Botanist who has been testing, among other crops, a collection of cowpeas for their fodder yields (see below)

There is no doubt that there is a wealth of varying types and ecotypes within the important grass genera of India. For example, there is within the species *Dichanthium annulatum* a very wide range of growth forms from highly reproductive types with a few flowering stems to almost completely leafy vegetative types of apparent high value for grazing or cutting. The same observations can probably be made on other important grasses such as *Cenchrus ciliaris* or *Cynodon dactylon*. Wide variation in growth form appears to be available if it should be required.

Indian Agricultural Research Institute

Until information becomes available on the ecology of Indian pasture species and their specific agronomic characteristics, it is not considered either possible or desirable to evolve complex breeding techniques. Breeders must first decide upon the particular species of grasses and legumes, indigenous or introduced, which should be included in the breeding plans ; the desirable and undesirable attributes of the species and strains must be clearly understood.

Breeding of pasture species began in the Division of Botany at I. A. R. I., New Delhi, in April, 1953. On the basis of the information available regarding the composition of grasslands in the northern regions of India, and from preliminary observations made on indigenous and exotic material in the Agronomy and Botany Divisions of I. A. R. I., the following species have been selected for preliminary work :

Cenchrus ciliaris

'*Anjan*' is now recognised as a most important perennial pasture species in the semi-arid regions of northern India, being common in the areas which produce the Hariana cattle.

Objectives of breeding : increased growth, vigour and early spring growth.

Cenchrus setigerus

This species is frequently associated with *C. ciliaris* in natural pastures.

Objectives : as for *C. ciliaris*

Chrysopogon montanus

This drought-resistant grass is found in the plains and the lower ranges of hills of northern India.

Objectives : Breeding for satisfactory spring growth ; North Indian material has spring growth but is not prolific ; Nagpur (M. P.) strain is vigorous but is a monsoon type.

Pennisetum orientale

Common and aggressive in the elevated areas of northern India ; characterized by early leaf growth in the spring.

Pennisetum nervosum, P. polystachyon (thin Napier) and *P. pedicellatum.* These species may provide breeding material for the improvement of leafiness in *Cenchrus ciliaris* and *Pennisetum orientale.*

Chloris gayana

Objectives : increasing vigour and yield and improving quality.

Pueraria hirsuta (kudzu vine)

Objectives : introducing winter hardiness; the common type is vigorous but susceptible to cold, a strain from Assam is less vigorous but is cold resistant ; as the common kudzu flowers a month earlier than the Assam strain, flowering would have to be synchronized or pollen stored for purposes of crossing.

It is proposed to collect indigenous material from different parts of India during the Grassland Survey and to compare this with introduced material. The more promising species, particularly the perennials, will be chosen for further breeding. For the conditions of northern India, greater attention will be given to grasses and legumes resistant to high temperatures and drought. In the preliminary trials of some indigenous and exotic strains of species of *Cenchrus, Pennisetum, Dichanthium, Chrysopogon,* etc. grown in a purely rainfed area, an Australian strain of *Cenchrus ciliaris* was conspicuous for its drought-resistance and resistance to heat. In this strain, shoots remained green almost throughout the year.

Ultimately it is hoped to improve the best types by single plant or mass selection or by hybridization. Before such work can begin, information will have to be collected on the fertility relationships within each species, or the degree to which they are self- or cross-fertile.

Information collected so far has shown that *Cenchrus ciliaris, C. setigerus, Dichanthium annulatum, Pennisetum orientale, P. pedicellatum, P. nervosum* and *P. polystachyon* are all fairly self fertile ; *Chrysopogon montanus* did not set any seed under the bag and requires to be further investigated.

In self-pollinated species, the selection of promising plants for seed multiplication would lead to rapid initial improvement. It should be worth studying the effect of mass selection in open-pollinated populations of self-sterile but cross-fertile material. In unselected bulk lots of indigenous species, the considerable variation to be expected should offer great scope for selection. After more intensive study, it may be found necessary to adopt hybridization in order to combine certain desirable characters. Inter-varietal crosses have already been attempted in *Cenchrus ciliaris, Chrysopogon montanus* and *Pueraria hirsuta.* Even if some of the resulting material were found to be wholly or partially sterile, it may be possible to consider propagating them vegetatively; this might apply in the improvement of *Cenchrus ciliaris* by crossing with species like *Pennisetum nervosum, P. orientale. P. pedicellatum* and *P. polystachyon.*

The actual technique of crossing still awaits investigation; little is known about the use of hot-water treatment for emasculation of grass florets. Treatment of the whole spike of *Cenchrus ciliaris* with water at 50°C for six minutes inactivates the pollen without injuring the pistil; similar treatment produces the same result in *C. setigerus* in four minutes. In *Chrysopogon montanus,* treatment with water at 49°C for nine minutes is effective.

Ultimately, when suitable material has been built up, it may be considered beneficial to try the polycross nursery technique for the evaluation of selected, single plants of cross-pollinated species. The plants ultimately selected would form the basic material for the multiplication of seed of improved strains.

College of Agriculture, Dharwar, Bombay

Introduction of species

In 1945, Sir William Jenkins, then Agricultural Commissioner, brought a large collection of forage grasses and legumes from the United States which were tested for their suitability at three centres in Bombay State. Poona was one of them. In 1948, these tests were merged in a five-year scheme for the improvement of grasses and leguminous forage crops of Bombay State. The work under this scheme included :

(a) introduction and acclimatization of superior forage grasses and legumes (both exotic and indigenous) :

(b) improvement of indigenous grasses and legumes;

(c) methods of establishing swards, and

(d) balancing pasture herbage.

Work on the first two items has been continued since that date and several introductions have proved suitable for different parts of Bombay State. The work on the remaining two items has not progressed far enough for valid conclusions to be drawn.

Yield trials of introduced grasses

Two determine the suitability and superiority of the introduced grasses, a yield trial was undertaken over a period of four years (Table XCIII) at the Manjri *Kuran* area on medium black soil. The plots were given light irrigations once a month during the hot months (December to May) every year.

The introduced grasses were compared with *Dichanthium annulatum* as far as the number of cuts per year were concerned. Several of the exotic species have yielded as high or higher than *D. annulatum* and are capable of giving three to four cuts per year. The fluctuations in yield from year to year observed in all the grasses are due to variation in climate. Grasses No. 1, 2, 3, 5, 6, 11, 12, 13, 17 and 20 gave satisfactory yields and sufficient cuts per year.

Yield trial of forage legumes

A yield trial of some local pasture legumes including *Alysicarpus rugosus* (shevra), *Indigofera glandulosa* (barbada), *Heylandia latebrosa* (pivali godhadi), *Indigofera linifolia* (pandhar phali) and *Desmodium diffusum* (patada sherva), with two exotic legumes, Hubam sweet clover and Emerald sweet clover, was conducted over two seasons. *A. rugosus* gave the highest yield of green fodder (about 10 to 13,000 lb.) followed by *Indigofera glandulosa* and *Heylandia latebrosa*. The sweet clovers are more adapted to a temperate climate and did not do well.

Further introductions

From time to time, seeds of exotic grasses and legumes have been obtained from different places, both within and outside India, for trial first in the nursery and later in the test plots. Of the 250 grasses tested, the following have been promising and are being multiplied for distribution (p. 312) :

TABLE XCIII

Yields of introduced grasses in Bombay State

Species	Green fodder yield			
	1st year 3 cuts	2nd year 3 cuts	3rd year 4 cuts	4th year 3 cuts
Tricholaena repens	37,092	23,420	14,388	No cuts
Panicum sp.	34,848	25,608	22,836	9,372
P. laevifolium	42,768	30,424	24,684	9,564
P. virgatum	1,320	*	24,948**	5,412
P. antidotale	16,500	32,604	15,576	4,224
Eragrostis superba No. 2031	22,440	29,832	24,024	8,316
E. superba No. 3941	25,476	33,792	25,344	7,392
E. lehmanniana	2,508	*	22,572**	6,204
E. chloromelas	8,712	10,336	11,220	3,168
E. curvula	10,560	24,288	19,668	4,752
Pennisetum polystachyon	28,512	48,048	39,864	13,200
Cenchrus ciliaris	42,504	34,980	29,568	5,996
Chloris gayana	23,892	21,648	22,672	9,240
Anthouschmideta bulbosa	11,220	*	20,332**	6,072
Bouteloua filiformis	2,253	*	19,008**	5,280
Paspalum notatum	4,768	5,280	15,840	2,772
Panicum maximum	30,319	41,154	36,432	11,880
Dichanthium annulatum	37,240	47,652	29,832	8,976
Andropogon ischaemum	8,572	7,128	10,824	4,356
Setaria sp.	26,977	48,236	43,164	17,952

*The grasses could not be harvested during the second year.

**During the 3rd year, these species were replaced with a selection of *Dichanthium annulatum*.

Pennisetum polystachyon	Thin Napier
P. purpureum	Thick Napier
P. masaicum	—
P. pedicellatum	—
Panicum virgatum	Switch grass
P. maximum	Guinea grass
P. barbinode	Para grass
P. antidotale	Blue Panic
Panicum sp.	—
Chloris gayana	Rhodes grass
Cenchrus ciliaris	Anjan
Eragrostis superba	Veldt love
Tricholaena repens	Natal grass
Paspalum dilatatum	Dallis grass
Dichanthium annulatum	Marvel
Iseilema anthephoroides	Moshi
Ischaemum laxum	Pavna
Themeda cymbaria	Fulgavat
Setaria sphacelata	—
Setaria sp.	—

About 280 species and varieties of legumes have been tried; the following are being multiplied for distribution :

Pueraria phaseoloides (tropical kudzu)
P. thunbergiana (Japanese kudzu)
Leucaena glauca
Centrosema pubescens
Glycine javanica
Clitoria ternata
Desmodium uncinatum
D. nicaraguensis
D. diffusum
Desmanthus virgatus
Indigofera (creeping)
Stylosanthes gracilis

Calopogonium mucunoides
Tephrosia tinctoria
T. purpurea
Alysicarpus rugosus
Indigofera glandulosa
Indigofera sp.
Cajanus indicus (fodder type)
Various types of *Medicago*, especially rhizomatous.

Selection in indigenous grasses and legumes

Marvel (*Dichanthium annulatum*) is a palatable and nutritious grass, widely distributed in Bombay State. Selection was, therefore, considered to be most important. Seeds were received from widely different sources and plants grown in bulk in a trial plot. Variation was observed for characters such as habit, colour of stem, nodal hairs and time of maturity. Four hundred selections were made from 3,000 plants and grouped into five broad types. It was, however, observed that these types were not distinct, as several plants appeared to be intermediate in type. Therefore, a further selection of 117 plants was made from all types and progeny of the 117 plants was maintained for three seasons and their morphological characters and yield recorded. On the basis of these studies, the progenies were grouped into 18 types. After a comparative yield trial, the five best types were chosen for further trial and distribution. Selection within high yielding types is being continued.

Legumes occurring naturally in grasslands were collected and grown in bulk in plots. Two species, *Indigofera glandulosa* (barbada) and *Alysicarpus rugosus* (shevra), proved more suitable than others. Selection was, therefore, confined to these two species, which showed variation in habit, duration of growth and yield of green fodder. Four promising types in *Indigofera glandulosa* and three in *Alysicarpus rugosus* were isolated. The selected types are more leafy, palatable, have a longer period of growth, and seed profusely.

Hybridization

A cross between elephant grass (*Pennisetum purpureum*) and African *bajri* (*P. typhoideum*) has resulted in an F_1 hybrid generation with a wide range of segregation including types closely resembling the parents. The segregates resembling the *bajri* parent have set some seeds, while those tending towards the elephant grass parent and other intermediate types are completely sterile. The segregates show

variation in tillering, leaf length and width, thickness of culm and extent and intensity of anthocyanin pigmentation. In this last character, the F_1 segregates have shown intense pigmentation compared with only a trace in elephant grass and none in *bajri*.

Seeds and seed production

Parallel with the development of new and superior strains of herbage and fodder plants, research on the characteristics of their seeds will become essential. Little is yet known about the technique of seed cleaning, or of the nature of germination, and the loss of germination capacity with storage.

In Bombay, for example, it has been the practice to use seed in the condition in which it has been collected from wild or cultivated stands without separating the caryopsis from the glumes and other outer coverings. It was thus necessary to use many times the quantity of seed actually required and germination was less satisfactory. Cleaned seed has a higher percentage of germination. Hand cleaning has been compared with machine cleaning; although cleaning with a hammer mill does cause slight damage to the seeds, there is little difference in percentage germination between the two methods, and machine cleaning is fast and less expensive.

Studies have also been made in Bombay on the effect of duration of storage on germination capacity. The data shown in Table XCIV indicate trends over a two-year period. Attention should be drawn to the variation within the genus *Eragrostis* and to the rapid decline in viability in the species of the important indigenous genus, *Dichanthium*.

TABLE XCIV

Effect of storage on germination of grass seeds

Species	Percentage germination after storage for		
	One month	One year	Two years
Chloris gayana	93.33	85.33	46
Cenchrus ciliaris	59.65	44.00	20
Pennisetum polystachyon	100.00	68.33	40
Eragrostis curvula	80.00	83.00	98
E. superba	47.00	71.00	63
E. chloromelas	37.33	43.00	82
Panicum antidotale	85.65	83.00	80
Tricholaena rosea	79.12	65.60	57
Dichanthium caricosum	47.00	21.00	5
D. annulatum	69.00	21.33	6

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The technical programme of the Teaching Botanist, for the year 1954-55, contains the following items :

Fodder grasses : The chief objective is to isolate high yielding strains possessing :

(a) succulence, palatability and high nutritive value.

(b) Extensive matty root system and spreading or profusely tillering shoot growth for soil binding and conservation.

(c) Capacity to withstand trampling and cutting or grazing.

(d) Capacity to compete with undesirable coarse grasses occurring naturally in the grassland.

(e) Drought resistance.

Isolation of strains and multiplication

This is to be based on plant material collected from within and outside the State and on introductions from other countries. The yield trials of the annual and perennial strains will be continued both under non-irrigated and irrigated conditions. A preliminary yield trial of the selected improved strains will be carried out on 15 Government Farms. The new strains and isolates will be maintained and multiplied at Nagpur and seed supplied to development blocks and private individuals.

Reseeding, management and subsequent care of grasslands

The optimum seed rate of the departmental grass/legume mixture will be determined and also the combining capacity of the selected isolates with this mixture. Optimum time and frequency of cutting will be studied. The degree of compatibility of the new isolates with annual and perennial leguminous fodders will be observed. The suitability of old and new improved strains in suppressing three undesirable coarse grasses, namely kusal (*Heteropogon contortus*), ghuned (*Anthistiria ciliata*) and tikhadi (*Cymbopogon martini*) will be investigated.

Chemical composition of promising strains.

Palatability of new isolates.

Legumes : The main objective is to evolve high-yielding fodder types suitable for cultivation for fodder, for introduction in grass mixtures as catch crops,

double crops and dual-purpose crops. Combined experiments will be undertaken to determine the comparative fodder value of selected strains of several *kharif* legumes, namely :

Shevra (*Alysicarpus rugosus*)
Barbata (*Indigofera glandulosa*)
Popat (*Dolichos lablab*)
Velvetbean (*Mucuna* spp.)
Chaoli (*Vigna sinensis*)
Soybean (*Glycine soja*)
Guar (*Cyamopsis psoralioides*)

Rabi legumes being tested for *utera* cultivation in paddy tract include species of *Medicago*, *Melilotus*, *Trifolium* and *Trigonella*.

Miscellaneous fodder crops

Work on *juar*, maize, sunflower, rape and the lesser millets is being continued with the object of isolating types suitable either for green fodder, or dual-purpose for grain and dry fodder, or as catch crops and double crops. Promising strains of early and late *kharif* and *rabi juars* are being tested at Nagpur and several Government farms. The crossing work in *rabi juar* is being continued.

Fodder Research Section, Department of Agriculture, Sirsa, Punjab

We have already seen that the Punjab contains the greatest percentage of fodder crops per total crop acreage of any State in India. Work on the improvement of fodder crops, therefore, started long ago, with the appointment of a Fodder Specialist in the Agricultural Department in 1925, and the organization of a Fodder Research Section, first at Lyallpur from 1925 to 1934, and then at Sirsa from 1934 onwards.

The work has been concentrated respectively on breeding and improvement, and culture and production. The first has included selection, hybridization and acclimatization for greater productivity and better fodder quality, with progeny row tests and observations on the performance of varieties and strains. The work on culture and production has dealt with the effect on the production of fodder and seed of various fertilizers, time and method of sowing, irrigation and cutting practices. There are 65 acres at Sirsa and a further 2.5 acres at Palampur, Kangra District, for work on hill grasses.

The crops dealt with include those listed in Table XCV, some cultivated grasses (Napier, Guinea and Rhodes), some indigenous pasture grasses (*Cenchrus ciliaris*, *Dichanthium annulatum*, *Cynodon dactylon* and *Eleusine flagellifera*), and a number of hill grasses being studied at Palampur. The demand for seed of the improved varieties produced by the Section is much greater than the supply available, as will be seen from Table XCV.

Seed distribution

There is at present no organised industry for the production, certification and distribution of seed of improved strains of herbage and fodder plants. Obviously consideration will have to be given to such a development if and when superior strains become available and are required by the farmers and cultivators. The production of these crops, always a difficult and specialized operation, will probably have to be carried out on Government Farms or on the larger, private properties which can acquire the necessary techniques and specialized equipment. As to the certification and control of quality of seeds, there are sufficient examples from other countries which might, with advantage, be studied. Distribution would probably be organized through the co-operative seed stores which already deal with seeds of other crops.

The first stage of multiplication of improved strains in Uttar Pradesh is done at the Government Farms, which have been established in nearly half the districts of the State. The programme resembles that prepared for *mung* Type 1, which is as follows. A nucleus of about 500 mds. seed is produced at the Government farms, ten maunds at each farm. In the following year, ten maunds of seeds are allotted to the District Agricultural Officer of each district who supplies it to selected growers and also multiplies some at the Government farms. The seed is purchased from the growers, either on cash payment or realised on a one and-a-quarter (*sawai*) basis in case the seed had been given as a loan, and then supplied to the Agriculture Department seed stores located at the *tehsil* (sub-division of the district) headquarters.

Further stages of seed distribution are the responsibility of subsidiary seed stores, located in several villages and townships and managed by the Co-operative Department, and in some places by the Cane Development Department. At present the Planning Department is active in this field, especially in the community project areas, by collecting and distributing the seeds, but outside these areas this

Department helps by co-ordinating the work of the Agriculture, Co-operative and Cane Departments. In the meantime the Government farms have to keep on raising the nucleus stock of pure seed every year and pass it on to the districts. The quantities of seed of wheat and rice multiplied by these farms is much larger than in the case of *mung* Type 1, as the improved varieties of these crops have long been in demand. Most farmers find them convenient and profitable to grow as they help them to reach the targets set for the overall production of the respective farms.

There is no special organization for the control of the supply of seed of improved varieties of fodder crops in the Punjab. Seed raised as part of the research work at the Fodder Research Section, Sirsa, is supplied to Government Institutions and farmers. Some 300 to 400 maunds are produced annually, but the demand is always greater than the supply available (See Table XCV).

TABLE XCV

Supply and demand for fodder crop seeds in the Punjab

Crop	Annual production (in mds.)	Varieties	Annual demand (in mds.)
Juar	70-80	J.S. 20, J.S. 263	6,000
Sudan grass	10		26
Teosinte	15-30		69
Cowpeas	15-20	FOS No. I	136
Guar	30-40	No. 2	172
Moth	5-10	Type 3	—
Berseem	20-25		250
Lucerne	7-10	Nos. 8 and 9	24
Oats	120-130	*Early maturing* : Weston II, Brunker 10 and I P.Hyb. 3 *Late maturing* : Algerian, FOSI/29	425
Rape	20-22	Japan	15
Senji	10-15	RIS. No. 1	18
Metha	6	No. 8	14

CHAPTER XV

MIXED FARMING

Sir John Russell (1937) observes that "a wide introduction of fodder crops into Indian agriculture would probably effect a great improvement in yields and in the total output. More food for the animals would mean more manure and enhanced fertility of the soil. This was the prime factor in the improvement of British agriculture and the additional yields of grain more than compensated for the area taken from grain and put under fodder crops."

Dr Norman Wright stresses the same point (1937). "The solution of the problem appears to be along the lines of the development of a 'mixed farming' system. In such a system, the production of animal products such as milk is carried on side by side with the system of cropping in which leguminous fodder crops take an important place and in which full use is also made of the increased quantities of cattle manure."

It is the main thesis of this book that increased production of cultivated fodders must be a primary objective of development in India, since this would :

(a) make it possible to take the strain off the natural vegetation (grassland and forest),

(b) bring increased fertility to cultivated land and higher yields of arable crops, and

(c) provide animal feed of far higher quality than that which can be provided by natural grazing.

We have in Chapter VII discussed the present position and possible extension of fodder production in India. There is no doubt that the interpolation of a legume break in the existing rotations wherever possible would improve fertility, whether this is due to the nitrogen or organic matter provided by the legume or to the after-effects of phosphatic fertilizers plus legume nitrogen on the yields of succeeding crops. British exponents of the system of "ley farming" would probably wish to see this tested under Indian conditions ; such investigations should be concerned with the effects of a high-producing grass/legume grazed pasture in a system of crop rotation. The growing and harvesting from the field of a legumi-

nous fodder crop is considered to go only part of the way to this ideal, which has the additional factors of the grass roots and the dung and urine dropped by the grazing livestock. Such a system adapted to Indian conditions certainly does deserve a fair trial, but it is difficult to see how it can be applied in a country where food crop and cash crop production is the primary objective, and where the conditions of land tenure and agrarian structure are of the type described in Chapter XVI. Some ley-farming trials have in fact been carried out by the Indian Agricultural Research Institute.

Indian Agricultural Research Institute

Three mixed-farming holdings were laid out at the Institute Farm in 1941/42 under irrigated conditions; the areas of the representative holdings were 8.8 and 7.5 respectively. Holding No. II was green manured once in two years and Holding No. III twice in three years ; no green manuring was practised on Holding No. I, some land being kept fallow, and a *kharif* legume fodder being grown in place of the green manure. The object of the experiment was (Sen and Sher Singh Bains, 1952) :

(a) to maintain the soil fertility at a high level as determined by the yields of crops per acre,

(b) to find out the relative merits of green manuring versus fallow and fodder cultivation,

(c) to compare the production of crops under the three systems of cropping and manuring, and

(d) to produce enough food for a family of five members equivalent to 4.3 adult units, and feeds and fodders for five head of livestock.

The yields of wheat and barley obtained from the green-manured holdings were significantly higher than those obtained from the fallow/fodder-crop holding ; the differences in the case of maize and *juar* were not significant. The output of grain was higher in the green-manured holdings. The family can provide the labour required for farming the holding. The production of grain and fodder from all these holdings was adequate for the human and livestock population; in fact a small surplus was available. It would have been interesting to see the effect of grazing of a palatable green manure crop *in situ* ; that much extra feed would be utilized and the return of fertility to the soil would probably not be significantly affected.

Experiments in Bombay

Trials at the Institute of Agriculture, Anand, have shown that an irrigated holding of 5 acres is adequate to produce food and fodder for a family and its livestock. The Institute is now studying irrigated holdings of 2½ acres, each with a cow and two calves, and sharing the working animals between six owners.

A cropping scheme for mixed farming experiments has been introduced at five Agricultural Schools in Bombay State, at Nasik, Dohad, Bagalkot, Manjri and Koshad. An area of 12 acres is first divided into two blocks of six acres each, called the Experimental and Control Blocks. Each Block is further divided into sub-blocks A and B and into plots 1 to 6, each of one acre.

Two three-course rotations are suggested in each block. The cropping scheme in Block I (Experimental) is centred around the production of 46,000 lb. green fodder, 20,000 lb. dry fodder and some food grains for the family. The cropping scheme for Block II (Control) is more or less similar to that adopted by cultivators in the tract covered by the School.

Each School has set aside four buffaloes of good breed which are tied separately; the dung, urine and straw are being treated by the hot fermentation method. The milk is sold at current market rates, so that the economics of the two systems may be compared. Soils will also be analysed. As the benefits are necessarily of a long-term nature, a complete cycle of rotations (3 years) has to be completed.

Experiments under Indian Council of Agricultural Research

The Indian Council of Agricultural Research prepared a scheme for the simultaneous investigation and demonstration of mixed farming, which was operated with local modifications in four Provinces of undivided India between 1941 and 1946 (United Provinces, Northwest Frontier Province, Central Provinces and Berar, and Sind).

Holdings were to be selected as having reliable and progressive cultivators, either owners or tenants, who would change to mixed farming under direction and advice from the Provincial Department of Agriculture. With each such holding would be associated, as controls, two ordinary arable farms in the same locality. Areas were to be about equal and suitable for management with one pair of bullocks or buffaloes (about eight acres in U. P., 20 in N. W. F. P., 26-30 in C. P. and 16 in Sind). In each Province, several such blocks of three holdings were to

be taken to represent different regions. The mixed farms would acquire two good milch cows or buffaloes (or, in some areas, the equivalent in sheep or goats); they would receive a loan to cover the purchase, and grants in aid of initial expenses, of maintenance and of conversion of cultivation practices to those appropriate to mixed farming. Careful supervision of cropping and recording (especially on the mixed farms), as well as advice on the conversion of holdings to mixed farming, were to be provided by special staff in addition to the district agricultural staff.

Although the average arable farmer would already have a pair of bullocks and perhaps other livestock (especially in C. P.), the addition of milk cattle should be followed by a change in cropping, the growth of more fodder, and eventually an enrichment of the land. Dairy produce should bring a cash income and also improve the diet of the farmer and his family. The I. C. A. R. scheme provided for the collection of data on crops, income and expenditure from all farms over a period of several years, from which an assessment of any economic advantage for mixed farming could be made.

Finney and Panikkar (1953) have reviewed all the data available in the annual reports of the Provinces concerned ; the only publications referring to these experiments are those Ibne Ali (1950) and Raheja and Obhrai (1953). Finney and Panikkar note that Ibne Ali made useful comments about the advantages of the mixed farming in Uttar Pradesh, but did not consider the possibility that anything other than mixed farming could explain the extra profits obtained : likewise Raheja and Obhrai assumed that all differences in profits and yields between mixed farms and controls were the result of the introduction of mixed farming.

The differences between mixed farms and controls in respect of profits and yields were, according to Finney and Panikkar, not at all what would be expected from the slow improvement of holdings consequent upon the introduction of mixed farming. Since this question is of such great importance in many countries at the present time, Finney and Panikkar's interpretation of the I. C. A. R. results and their suggestions for an improved investigation are quoted in full.

"Certain major flaws in the experiment may explain the results. Holdings for mixed farms were admittedly chosen because of good management and suitability to act as demonstrations for their neighbourhoods ; they were, therefore

almost certainly initially in better condition. Moreover, supervision of the mixed farms and close observation of progress must have necessitated much more frequent visits by supervisory staff from the Departments of Agriculture than the control farms received. This tendency would be present even if the investigation had been purely experimental, but would be greatly strengthened by the wish to maintain good demonstrations. Not only would these farmers thus have more opportunities for receiving advice on crop and animal husbandry than would the controls, but they would be more capable of benefiting from it.

"To assess the extent to which these factors contributed to the extra profits on the mixed farms is impossible. If accounts and other records had been kept for a preliminary year, on all holdings, before the introduction of mixed farming, they would have given some information on initial differences. The holdings in C. P. were subject to the factors of selection and advice favouring the mixed farms just as in U. P. and N. W. F. P., although true mixed farming was not practised ; the results are of no use for estimating the magnitudes of the biases produced elsewhere, however, since these biases would vary from Province to Province.

"Thus the true explanation of the differences found between records from the mixed farms and those from the controls appears most probably to lie in factors inherent in the planning and conduct of the investigation and not in mixed farming itself. To say this is in no sense to deny that mixed farming can be beneficial. Benefits to soil fertility, and thereby to farm profits, cannot appear quickly and would be unlikely to be demonstrated by an investigation of this character in three or four years. No attempt was made to determine any improvement in the health of cultivators and their families resulting from increased consumption of dairy products.

An improved investigation

"A more satisfactory study of the economics of mixed farming would require three major improvements over the scheme described here. First, it should be free from any notion of demonstrating a pre-conceived opinion that mixed farming is advantageous ; within the framework of the scheme, the mixed farming practised could be regarded also as a demonstration to neighbouring cultivators on how to introduce milch animals into an arable farm, but to start with an assumption that this is a better method of farming may vitiate the attempt to assess its value.

"Secondly, three types of holding should be compared instead of two; those having no interference with their normal arable routine, those changing to mixed farming under advice from their Department of Agriculture and those having similar close supervision and advice on crops but without additional livestock.

"Thirdly, in agreement with experience in all other types of agricultural research, the only true safeguard against initial and intrinsic differences between holdings and differences in farming skill should be employed; sets of three roughly similar holdings in a locality should be chosen for study, and from each such set one should be selected strictly at random for each of the three 'treatments'.

"The experiment should of course be restricted to regions in which mixed farming is practicable. Every effort should then be made to secure that each participating State or other authority conforms to the standard pattern, and major deviations such as those that occurred in C. P. should be regarded as falling entirely outside the investigation. Additions to the livestock beyond those needed for the experiment should be avoided, at least for the first few years. Recording would need to be just as full as for the earlier scheme, but, in the light of experience gained from the conduct and analysis of this, fresh thought should be given to the ideal form of accounting. For example, the manner of accounting for family labour and family subsistence, and the recording of expenditure and income appropriate to livestock and crops separately need careful examination. Special subsidies and grants to cultivators also need more thorough accounting than in the past. Attempts should be made to secure, from all holdings, some measure of the quantities of farmyard manure produced and the crops on which it was used. To maintain all these records for one complete year before the experiment proper began would give further interesting information, but this is not essential. The experiment should continue for at least five years".

CHAPTER XVI

AGRARIAN STRUCTURE

LAND TENURE, SIZE OF HOLDING AND CONSOLIDATION

THE chief deterrents to the provision of animal fodder on a year-round basis in India may be said to be the monsoon climate and the agrarian structure. Under the second head we have to consider first the size of holdings. We have seen in Chapter XV that it is possible to feed a family and their essential livestock on an irrigated holding of 7.5 acres, provided due importance is given to the inclusion of green manures and fodder crops in the rotation. A rain-fed holding depends for its crop production on the *kharif* crops produced under the monsoon and on such *rabi* crops as can be grown on the residual moisture available after the *kharif* crops have been harvested plus the second monsoon in certain areas or the "Christmas rains" in others. Probably such a dryland holding would have to be at least 25 acres in size to maintain the family and its livestock and give some cash return on the surplus.

An indication of the position regarding average size of holdings is given in Table XCVI quoted from the "First Five-Year Plan".

An important reason for the poor productivity of Indian agriculture and the low income of the large majority of farmers is the small size of the individual production unit and the consequent uneconomic methods of cultivation. The situation is summarized in a different way in Table XCVII.

The problem has three aspects (Government of India, 1950) : the holdings are not only becoming smaller due to constant sub-division, but each individual holding is tending to become dispersed in a number of fragmented plots each too small for profitable cultivation. The evil has tended to grow with every increase in population and the failure of secondary and tertiary industries to expand in proportion. The prevailing law of inheritance and succession has only accelerated the process, which is proceeding in almost all States in varying degrees of intensity; in the Punjab the number of holdings below three acres increased from 43.4 per cent of the total in 1928 to 48.8 in 1939; in Madras the number of *pattadars* (owners of land) paying Rs. 10/- and less increased from 69.5 per cent of the

Table XCVI

Size of holdings in the States of the Indian Union
(Proprietory and occupancy holdings)

(Quoted from the "First Five-Year Plan")

Size group acres 1	Number of holdings 2	Percentage of holdings 3	Area (acres) 4	Percentage of area 5	Remarks 6
Uttar Pradesh :					
0—5	9,971	81.2	16,024	38.8	The entire occupied area prior to merger, which was 90 per cent of the present occupied a ea, was included in the inquiry
5—10	1,563	12.7	10,824	26.1	
10—16	440	3.6	5,464	13.2	
16—25	190	1.6	3,694	9.0	
Over 25	114	0.9	5,310	12.9	
Total	12,278	100.0	41,316	100.0	
Bombay :					
0—5	1,313	52.31	3,672	14.00	Figures relate to the entire ryotwari area prior to merger
5—15	707	28.18	6,548	24.95	
15—25	274	10.90	5,163	19.68	
25—100	201	8.02	8.114	30.92	
100—500	14	0.57	2,314	8.82	
over 500	1*	0.2	428	1.63*	*The actual number is 562
Total	2,510	100.00	26,239	100.0	
Madhya Pradesh :					
0—5	1,296	51.5	2,856	10.0	Figures relate to 77 per cent of the total occupied area of the State. The remaining 23 per cent area not covered by the inquiry forms part of the merged territories
5—10	493	19.5	3,528	12.0	
10—20	375	14.8	5,656	18.6	
20—50	269	10.7	8,453	28.9	
50—100	63	2.5	4,110	14.0	
100—500	26	0.9	3,680	12.9	
over 500	0.93	0.04	1,067	3.6	
Total	2,522.93	100.0	29,350	100.0	

Table XCVI—contd.

Orissa:					
0—5	N. A.	74.2	N. A.	30.1	The data are based on a sample survey conducted in different parts of the State covering an area of 60,230 acres
5—10	N. A.	15.3	N. A.	22.0	
10—20	N. A.	7.1	N. A.	20.8	
20—50	N. A.	3.0	N. A.	17.1	
50—100	N. A.	0.3	N. A.	4.1	
Over 100	N. A.	0.1	N. A.	5.9	
Total		100.0		100.0	
Bihar :					
0—5	N. A.	83.3	N. A.	N. A.	The data are based on a sample survey which was not considered adequate. The figures are, therefore, to be taken as indicative of the general situation
5—10	N. A.	3.4	N. A.	N. A.	
10—15	N. A.	7.8	N. A.	N. A.	
15—30	N. A.	2.5	N. A.	N. A.	
30—50	N. A.	2.0	N. A.	N. A.	
Over 50	N. A.	1.0	N. A.	N. A.	
Total		100.0			
Assam :					
0—5	N. A.	66.1	N. A.	26.0	The sample survey relates to 26,000 acres comprised in 5,295 holdings
5—10	N. A.	22.5	N. A.	32.9	
Over 10	N. A.	11.4	N. A.	41.1	
Total		100.0		100.0	
Madras :					
Holding assessed on :					
1. Rs. 10 and less	5,906	82.2	11,356	41.2	The data relate to the ryotwari area which represents *pattas* 82 per cent of the total area and represent estimates
2. Over Rs. 10 but not exceeding Rs. 30	822	11·4	7,504	27.2	
3. Over Rs. 30 but not exceeding Rs. 50	264	3.7	2, 82	10.2	

4. Over Rs. 50 but not exceeding Rs. 100 (23—45 acres)	137	1.9	2,337	8.5	The holdings include joint *pattas*. The area comprised in individual holdings in the larger size groups may, therefore, be considerably smaller
5. Over Rs. 100 but not exceeding Rs. 250 (45—114 acres)	46	0.6	1,692	6.	
6. Over Rs. 250 (Over 114 acres)	14	0.2	1,876	6.9	
Total	7,189	100.0	27,591	100.0	
Mysore:					
0—5	820	66.2	2,061	25.3	The entire area of the State was Included in the inquiry
5—10	265	21.2	2,002	24.0	
10—50	144	11.4	2,898	35.0	
50—100	11	0.9	856	10.3	
100—500	2	0.2	379	4.6	
Over 500	0.1	0.1	67	0.8	
Total	1,242	100.0	8,263	100.0	
Travancore-Cochin:					
0—5	1,541	94.1	1,322	44	
5—10	56	3.4	368	13	
10—15	21	1.3	253	9	
15—25	11	0.7	207	7	
25—50	4	0.3	158	5	
50—100	2	0.1	118	4	
Over 100	1	0.1	493	18	
Total	1,636	100.0	2,914	100	
PEPSU:					
0—5	239	45.4	518	8.2	
5—10	93	17.6	680	10.7	

Table XCVI—contd.

10—20	107	20.3	1,572	24.8	
20—50	771	13.4	2,072	32.6	
50—100	—	—	543	8.6	
100—500	17	3.3	227	3.5	
Over 500					
Total	527	100.0	6,347	100.0	
Delhi :					
0—10		Not available			
10—20	30	N. A.	10	N. A.	
20—50	1	N. A.	45	N. A.	
50—100	0.2	N. A.	17	N. A.	
Over 100	0.1	N. A.	13	N. A.	
Total	31.3	—	85	—	
Himachal Pradesh:					
0—5	69	95.0	83	71	The data relate to Chamba district only
5—10	2	3.0	13	11	
10—15	1	2.0	12	10	
Over 15	1	0.1	1	8	
Total	73	100.0	119	100	
Coorg :					
0—5	42	76.0	128	30.0	The entire area of the State is included
5—10	7	12.0	54	13.0	
10—15	3	5.0	31	7.0	
15—25	2	3.0	34	8.0	
25—50	1	2.0	31	7.0	
50—100	0.5	1.0	35	8.0	
100—500	0.4	1.0	95	23.0	
Over 500	0.02	...	15	4.0	
Total	55.9	100.0	423	100.0	
West Bengal :		Percentage of cultivators according to size of holdings			
		According to Flood Commission's report (Per cent)			According to the 1951 census (per cent)
0—2 acres		41.9			34.4
2—4 acres		20.6			27.6
Over 4 acres		37.6			38.0

TABLE XCVII

Size of holdings

	Madras (1)	Punjab (1)	U. P. (1)	Bengal (1)	Bombay	Mysore (2)	Assam (3)	Orissa (4)
Average size of holding (acres)	45	10.0	N. A.	4.4	13.3	6.2	4	4.9
Percentage of number of holdings under 5 acres to the total	82	63.7	81.2	71.3	41.9	65.9	66.4	79.2
holdings under 10 acres	89	80	93 9	88.3	60.9	86.7	87.4	89.5
,, under 15 acres	N. A.	87.9	N. A.	N. A.	72.5	N. A.	N. A.	94.3
,, under 25 acres	N. A.	93.7	99.1	N. A.	85.2	N. A.	N. A.	97.8

(1) Report of the Rural Banking Enquiry Committee Para 30.

(2) Report of the Land Revenue Revision Committee 1950.

(3) A survey of Rural Economic Conditions in Darrang, 1950.

(4) Report of the Land Revenue and Land Tenure Committee 1949, Appendix IX.

total to 87.65 per cent over a period of 20 years. Dr H. H. Mann showed that the average holding in a typical village in Poona district fell from 40 acres in 1871 to seven acres in 1914-15. A fall from 23 acres in 1889 to 14 acres in 1945-46 is reported from Hyderabad. Figures for Uttar Pradesh show the same trend.

The publication under review states, however, that with the abolition of *Zamindaris*, land reforms and simplification of land tenures the problem of consolidation is likely to become easier. Certain States have taken action to determine the minimum economic holdings applicable in their own areas, and the principle of controlling the unrestricted rights of transfer of land is widely favoured. Parallel with this, existing holdings will be consolidated compulsorily, due to the urgency of increasing productivity of land by every possible means. It is not known whether the figures accepted for minimum economic holdings are based on the idea of full integration of crop husbandry and animal husbandry,

with whatever variation of mixed farming or alternate husbandry which may be applicable.

Shifting cultivation

The wasteful practice of shifting cultivation is still prevalent in certain parts of India. In Madhya Pradesh, for example, it has been practised from time immemorial and is still to be found in the Mandla and Bilaspur forest divisions of the old Central Provinces and Berar, and in the backward tracts of the merged States, particularly in parts of old Bastar, Raigarh, Udaipur, Jashpur, Surguja and Kawardha States and in certain *Zamindaris* and *Jagirs* in Balaghat and Chhindwara districts. The tribes involved in this practice are 'Baigas' in Mandla, 'Baigas' and 'Bhumiyas' in Bilaspur, 'Gond-Baigas' in Balaghat, 'Bhariya-Gonds' in Chhindwara, 'Baigas' in Kawardha, 'Korbas' and 'Pandos' in Surguja and Jashpur, and 'Murias' in Bastar.

It is generally agreed that effective steps should be taken to put a stop to this primitive practice of cultivation as early as possible in the larger interests of the country and the welfare of the tribal people. The matter is under active consideration of the Tribal Welfare Department which has recently started operating in this State. The subject had also been discussed by the Forest Policy Committee set up by the State Government in 1947 and its recommendation to stop shifting cultivation effectively has been accepted by the State Government.

No scheme has, however, been prepared in Madhya Pradesh State to plant food and fodder trees in areas characterized by methods of shifting cultivation.

A detailed scheme drawn up by the Deputy Commissioner, Surguja, for settling Korbas for permanent cultivation has already been sanctioned by Government and is in operation. Suitable blocks of land mostly from village forests unoccupied and available for cultivation or in rare cases from the Reserve Forests have been selected in consultation with the Divisional Forest Officer for reclamation for cultivation. The 'Korbas' have been allowed some choice wherever possible. One block of land is given collectively to one group under a *mukhiya* (head-man) and the group is collectively authorized to reclaim the block. After the block is reclaimed, tenancy rights will first be given collectively to the group and then divided to individuals. No assessment will be charged for three years. Interest-free loans in the forms of *Taccavi* will be given for purchasing cattle, implements and seeds but payment will be made to persons from

whom the purchases are made. During 1950-51, the State Government sanctioned Rs. 2,50,000/- for granting interest-free loans and Rs. 14,800/- for contingent expenditure. By the end of March 1952, 7808 acres of land for 716 Korba and 762 Pandos families living in 236 villages had been brought under cultivation (Lakhpat Rai, 1953).

Typical Indian Villages

At several points in this review we have referred to the inadvisability of relying on all-India calculations and estimations based on data of doubtful statistical validity. We have stressed the fact that India is a land of villages and that it is on the basis of these that any really valid conclusions may be drawn. A thorough study of the agrarian structure of representative Indian villages would be very revealing, not only for planning in the country itself, but also as part of the modern subject of agrarian structure and reform. From the restricted point of view of this review, such information would indicate the extent to which improved methods of crop and animal husbandry might perhaps be adopted within the existing structure or the way in which that structure would have to be adapted to make an integrated stable form of agriculture possible.

When the original questionnaire was issued to States, a request was included for information on characteristic villages of the separate States ; data were required on human population, livestock numbers, area of cultivated land, and so forth. We will conclude this Chapter by presenting some of the information collected, without detailed comment or consideration as to how one might deal with each individual situation in the light of modern ideas of correct animal husbandry and feeding, mixed farming, maintenance of soil fertility, and other aspects. Such questions might well be incorporated as special fields of study under the Community Projects Administration, which interests itself in animal breeding and health, but rarely in nutrition.

TABLE XCVIII

BIHAR

Khajpura, Kotwali P. S., Patna

Human population		Livestock population		Total acreage
Male	500	Cow	116	343.75 (cultivated area for crop—281 acres; Grazing area— nil. Cultivable waste—62.50.)
Female	488	Buffalo	115	
	988	Others	131	

TABLE XCIX

BOMBAY

Pimple Sandgar, Taluka Haveli, District Poona

Human population	Livestock population	
1014	Bullocks	141
	Cows	85
	Young stock	100
	Buffaloes	135
	Young stock	43
	Sheep and goats	58
	Total	562

Size of holdings : 5 acres, 27 gunthas ; average size of proprietory holding

Acreage of cultivated lands: 1006 acres, 14 gunthas

Grazing area : 4 acres, 12 gunthas

Ownership of livestock : The total livestock is owned by 90 different owners in the village

Table C

MADRAS

Name of village	Name of District and Taluk	Representation of villages with
Manur Suguru	Bellary District, Siruguppa	Dry cultivation
Taluru	Bellary District, Siruguppa	Wet cultivation
Harivanam	Adoni	Potentialities for industrial development

The particulars collected in connection with a test survey are given below :

Description	Manur Suguru		Taluru		Harivanam	
1. *Population*	1153		1369		3172	
2. *Livestock* :	No.	Value (Rs.)	No.	Value (Rs.)	No.	Value (Rs.)
Plough cattle	346	41,520	269	45,730	549	89,020
Milch cattle :						
(i) Cows	195	9.750	80	4,800	181	10,860
(ii) She buffaloes	31	3,100	75	7,500	187	22,440
Calves :						
(i) Bull calves	110	2,200	65	2,600	128	5,120
(ii) Cow calves	77	770	46	460	108	1,620
(iii) Buffalo calves	16	240	55	720	81	1,520
Sheep	236	2,360	115 (Sheep and Goats)	1,725 (Sheep and Goats)	468	7,230 (Sheep and Goats)
Goats	380	5,320			14	
Horses	2	200	5	240	12	1,070
Pigs	...	...	26	130	23	115
Poultry	58	145	50	150	45	90
Total	1,451	65 605	786	64,055	1,796	139,085
3. *Family composition* :						
Total number of families	226		254		609	
Average size of the family	5.1 persons		5.4 persons		5·2 persons	

Table C—contd.

Description	Manur Suguru	Taluru	Harivanam
Number and percentage of earners	789 (69.6 per cent)	581 (42.4 per cent)	1,754 (55.3 per cent)
Number and percentage of dependents	344 (30.4 per cent)	788 (59.6 per cent)	1,418 (44.7 per cent)
4. *Occupational classification of families :*			
Primary services : Agriculture	182 (80.6 per cent)	191 (75.2 per cent)	434 (71.3 per cent)
Secondary services : industries	17 (7.5 per cent)	22 (8.6 percent)	62 (10.2 per cent)
Tertiary services : Professions and small traders	27 (11.9 per cent)	41 (16.13 per cent)	113 (18.5 per cent)
5. *Land utilisation :*		*acres*	
a) Gross area of the village	5,592.36	5,432.65	13,902.7
b) Net sown unirrigated area	4,585.6	4,992.22	13,295.6
c) Current fallows	793.8	27.44	61.4
d) Not available for cultivation	533	397.17	440.0
6. *Land Tenures :*			
(a) Ryotwari			
i) Total area	3,508.0	3,757.32	9,513.7
ii) Cultivated area	3,103.49	...	9,393.5
(b) Inam (Presentation land			
i) Total area	1,568.79	1,220.40	3,886.8
ii) Cultivated area	1,305.65	...	3,839.9
(c) Assessed waste			
i) Total area	288.44	16.11	39.2
ii) Cultivated area	162.41	...	15.8
(d) Unassessed waste			
i) Total area	19.10	...	17.2
ii) Cultivated area	...	...	6.5
(e) Poromboke (not available for cultivation			
i) Total area	527.95	438,82	445.8
ii) Cultivated area	14.08	...	39.9

Table C—contd.

Description	Manur Suguru		Taluru		Harivanam	
Distribution of holdings :	No. of ***Pattadars*	Total extent (Acres)	No. of ***Pattadars*	Total extent (Acres)	No. of***Pattadars*	Total extent (Acres)
(a) Less than *2* acres	3	5.07	13	10	79	91.2
(b) Between 2 and less than 5 acres	24	70.95	46	132	119	526.3
(c) Between 5 and less than 15 acres	76	748.06	64	582	286	3,167.6
(d) Between 15 and less than 50 acres	71	1,936.45	61	1,539	85	3,925.9
(e) 50 acres and over	10	653.73	17	1,836	40	5,689.5
Total	184	3 414.26	201	4,098	609	13,400.5

(** Title owner)

TABLE CI

ORISSA

Name of village	Human population	Average size of holding	Average of land in different crops	Acreage of grazing land including uncultivated and other wasteland
		A. Cents	A. Cents	A. Cents
Sisua	265	1—964	163—361	35—853
Kalyanpur	248	2—807	70—268	91—554
Bahabalpur	192	2—695	156—272	64—189
Raghabpur	568	1—650	238—323	524—162
Baharpara	423	1—760	498—349	81—787

TABLE CII

UTTAR PRADESH

Pilot Project Unit, Mahewa

Particulars	Names of the villages		
	Asadpur	Gautampur	Sonbarsa
1. *Total population:*	558	498	818
Average No. of persons per family	5.7	7.0	5.9
2. *Total cattle population*	347	353	515
Cows	30	28	44
Buffaloes	121	121	129
Bulls	33	48	120
Bullocks	73	89	122
Ponies	3	5	5
He goats	7	2	12
She goats	48	42	66
Sheep	...	...	1
Poultry	14	10	10
Pigs	15	7	6
Donkeys	3	1	0
Average No. of animals in each family	3.50	5.00	3.75
3. *Total No. of families :*	98	71	137
Land-owning	74	59	91
Land-less	24	12	46
4. *Average land holding :*	acres 4.25	acres 7.49	acres 5.01
Average holding under cultivation	4.08	7.031	4.74
Average holding out of cultivation	0.17	0.19	0.27
5. *Land acreage :*			
Total area of the village	346.63	396.27	506.69
(a) Under cultivation	323.27	314.88	440.48
(b) Out of cultivation	23.36	81.39	66.21
(a-i) Irrigated area	223.10	228.50	250.32
(a-ii) Unirrigated area	100.17	86.38	190.16

TABLE CII—contd.

Particulars	Names of the villages		
	Asadpur	Gautampur	Sonbarsa
6. *Total area under rabi crops:*	acres 216.54	acres 194.16	acres 277.60
(a) Irrigated	199.04	173.25	203.74
(b) Unirrigated	17.50	20.91	73.86
7. *Total area under kharif crops :*	188.77	165.96	271.27
(a) Irrigated	178.06	60.86	86.57
(b) Unirrigated	10.71	105 10	184.70
8. *Total area under zaid crops :*	1.74	0.20	0.75

TABLE CIII

PUNJAB

Particulars for three villages situated in Sirsa tehsil and irrigated by Western Jamuna Canal

Description	Khawakhera	Kaganpur	Khairpur
Human population	314	490	504
Livestock population :	217	262	188
Cows	30	65	17
Buffaloes	21	75	
Bullocks	45	90	69
Sheep	35	30	45
Donkeys	1	2	2
Ownership	cent per cent	cent per cent	cent per cent
Size of holding p r family	*acres* 12	*acres* 7.0	*acres* 12.5
Annual cultivable area per holding	10½	6.0	10.
Area of common grazing ground	53	93	125
Total area of village	483	494	693

TABLE CIV

HYDERABAD

District	Taluka	Village	Human population	Livestock population, i.e. plough cattle	Size of cultivation holdings of a family (five members)		Acreage of cultivated land			Grazing grounds		Ownership of livestock, viz. number of families
					A	G	A	G		A	G	
Medak	Medak	Chenna Ghanapur	1,683	400	21	22	1,887 1,526 360	6 37 9	 Dry Wet	883	21	246
Mahbub Nagar	Vanparthy	Addakal	1,165	541	62	8.6	2,197 1,614 575 7	14 32 6 16	 Dry Wet Garden	884	22	170
Gulbarga	Gulbarga	Farhabad	2,144	385	23	21.3	4,613 4,593 20	31 29 2	 Dry Garden	173	18	146
Osmanabad	Omerga	Takekur	1,685	641	29	15.5	5,940 5,649 82	39 8 23	 Dry Garden	28	37	326
Warangal	Mahboobabad	Edula Pusapalli	1,004	732	39	29.3	1,897 1,066 799 31	8 18 19 11	 Dry Wet Garden	167	22	197
Parbhani	Parbhani	Kumbakaran Takli	2,700	538	33	7	7,363	13	All Dry	65	22	206

Table CV

SAURASHTRA

Description	Madhya Saurashtra—District, Taluka—Rajkot, Villages			Sorath District, Taluka—Manavadar, Villages	
	Tramba	Sanosara	Lodhida	Indra	Limbud
1. *Human Population*	932	1309	275	1029	202
2. *Livestock Total*	1389	2131	554	741	63
Cows	135	124	60	140	17
Calves	74	104	20	78	—
Bullocks	156	231	40	191	30
Bulls (Uncastrated)	91	81	30	28	—
Breeding bulls	1	1	1	—	—
Buffaloes	62	40	50	98	12
Calves	43	39	15	39	—
Buffalo breeding bulls	1	1	—	—	—
Goats	250	284	100		
Sheep	556	1132	235	145	33
Horses	4	39	—	12	6
Mares	2	33	3	10	—
Donkeys	14	22	—	—	—
3. *Average size of holding (acres)*	50	50	—	34	30
4. *Acreage of Cultivated Land*	2582	3807	1302	2976	435
5. *Grazing ground*					
(a) Gujjars	1223	966	20	—	27
(b) Vidis	—	—	79	—	—

Table CVI

AJMER

Description	Ajmer sub-division					Beawar sub-division				
	Jethana	Gegal Akhri	Makhu-pura	Gagwana	Bhagsuri	Manglia-was	Beawar Khas	Kharwa	Masuda	Gopalpura
Total area in acres	11154	2301	2278	3782	3456	2564	3014	2010	9348	483
Total area under cultivation in acres	9006	705	585	1743	2500	988	1384	1035	2492	234½
Total area under forest	—	—	518	—	—	100	—	615	250	—
Total area available for grazing of livestock	1500	500	200	1500	800	46	645	415	480	81
Human population in 1951	2684	508	1392	1589	575	812	1122	1379	2900	295
Size holding in acres :										
Maximum	12	34	21	37	8	86	20	30	25	25
Minimum	.05	.07	.06	.09	.04	1	1	2	1	2
Average	2	2.8	0.7	4.3	2	6	3	5	4	4
Livestock population :										
(a) Cattle :										
Bullocks	457	157	258	238	110	148	224	140	200	50
Bulls	10	—	—	2	—	—	—	5	1	—
Milking cows	264	40	82	103	140	109	55	25	125	21
Other cows	687	83	130	189	132	314	57	220	60	29
Young stock	251	69	100	258	265	109	159	110	125	67
(b) Buffaloes :										

TABLE CVI—contd.

AJMER

Description	Ajmer sub-division					Beawar sub-division				
	Jethana	Gegal Akhri	Makhu-pura	Gagwana	Bhagsuri	Manglia-was	Beawar Khas	Kharwa	Masuda	Gopalpura
Bullocks	35	1	3	5	—	8	10	4	20	18
Bulls	6	—	2	1	—	2	—	2	1	—
Milking females	99	7	64	46	64	54	50	15	50	18
Other females	373	22	65	97	72	50	22	71	130	11
Young stock	281	7	61	67	203	45	101	31	50	19
(c) Donkey	47	3	21	25	—	—	22	26	—	5
(d) Pigs	30	20		45	—	—	29	21	30	—
Ownership of livestock :										
(a) Class of people owning majority of milch cows and buffaloes	Jat	Deswali	Rawat	Ahir	Gujar	Jat	Jat & Gujar	Khatik & Gujar	Jat & Gujar	Jat
(b) Class of people owning majority of sheep and goats	Jat	Deswali	Rawat	Ahir	Gujar	Rabari	Jat & Gujar	Khatik & Gujar	Jat & Gujar	Jat Gujar
(c) Class of people owning majority of donkeys	Kumhar	Kumhar	Kumhar	Kumhar	—	Kumhar	Kumhar	Kumhar	Kumhar	—
(d) Number of landless villagers owning cattle	50	30	30	60	30	10	20	35	50	3

(e) Number of villagers owning less than 5 acres of cultivated land and maintaining at least five head of cattle (cows, buffaloes and bullocks)	65	16	100	40	16	4	77	43	—	32
(f) Number of villagers owning from 5 to 10 acres of cultivated land and maintaining more than ten head of cattle (cows, buffloes and bullocks)	135	35	70	40	18	7	15	65	7	7
(g) Number of villagers owning more than10 acres of cultivated land and keeping more than ten head of cattle (cows, buffaloes and bullocks)	95	25	40	35	9	3	11	35	10	4
(h) Number of villagers possessing cattle and having no access to grazing in the *shamlat* and other grazing areas of the village.	210	20	30	11	21	3	7	30	—	1

TABLE CVII

BHOPAL

Land use particulars	Dahod	Amoda	Singaldeep	Tigaria	Deevatia	Gondermau
1	2	3	4	5	6	7
Total population	732	310	235	110	889	462
Total area in acres	4,816.86	1,283.72	1,191.12	1,979.39	3,457.82	2,209.26
Total No. of *Khatedars*	175	18	38	39	267	49
Landless Labourers	6	30	40	21	51	53
Other occupation	16	1	4	—	45	10
Nature of soil	*Kali No. 1 and 2*	*Kali No. 1 and 2 and light soil*	*Kali No. 1*	*Kali No. 1 and 2*	*Kali No. 1 2 and 3*	*Kali No. 1 and 2*
Cultivated area in acres	2,420.75	332.47	821.36	343,93	1,369.91	1,149.06
Uncultivable land in acres	1,814.32	270.54	304.47	560.23	2,170.28	380.21
Forest in acres	1,279.64	7 .91	—	1,050.83	252.17	—
Grassland (for cutting only) in acres	455.75	—	48.94	60.00	30.15	—
Breeding bulls	—	—	—	—	—	2
Working bullocks	360	146	153	60	408	177
Other bulls	66	28	17	24	93	23
Cows	335	105	100	119	425	168
Young stock	266	55	115	65	322	168
He buffaloes	16	—	10	2	8	7
She buffaloes	71	12	24	40	92	76
Young stock	57	8	21	14	53	75
Sheep	69	—	—	—	95	—
Goats	220	—	—	—	160	—
Horses	5	—	7	—	2	—

The cattle go for grazing in Nistar land or nearby forest areas.

TABLE CVIII

BILASPUR

Particulars relating to 342 villages (hamlets) of the Community Project Block Area (Sadda Block)

Population	36,746
Households	6,945
Area (total)	acres 84,713
Forests	3,928
Barren uncultivated land	16,325
Uncultivated land not classified under forests	38,877
Current fallows	517
Net sown area	25,606
Total livestock	495,64
Oxen :	No.
(a) Breeding bulls	—
(b) Working bulls	11,404
(c) Other bulls	631
(d) Cows	6,409
(e) Young stock	3,699
Buffaloes :	
(a) Males	261
(b) She buffaloes	9,282
(c) Young stock	3,308
Sheep	5,069
Goats	9,324
Horses and ponies :	
(a) Horses	31
(b) Mares	132
(c) Young stock	14

CHAPTER XVII

GRASSES AND LEGUMES

CULTIVATED AND INTRODUCED GRASSES

Brachiaria mutica. Stapf Paragrass, Mauritius grass, Buffalo grass

A coarse perennial grass, 1 to 2.5 m. high, stem rhizomatous with ascending branches, leafblade linear, up to 30 cm. long, 6 to 16 mm. wide, glabrous (rarely hairy), margins scabrid. The rhizomes freely root at nodes and extend quickly up to 10 m. in length. Culms are hollow, glabrous with hairy nodes. Panicles oblong or ovate-oblong in outline, 6 to 20 cm. long, common rachis round, channelled above. Racemes many, shortly peduncled or sub-sessile, obliquely spreading.

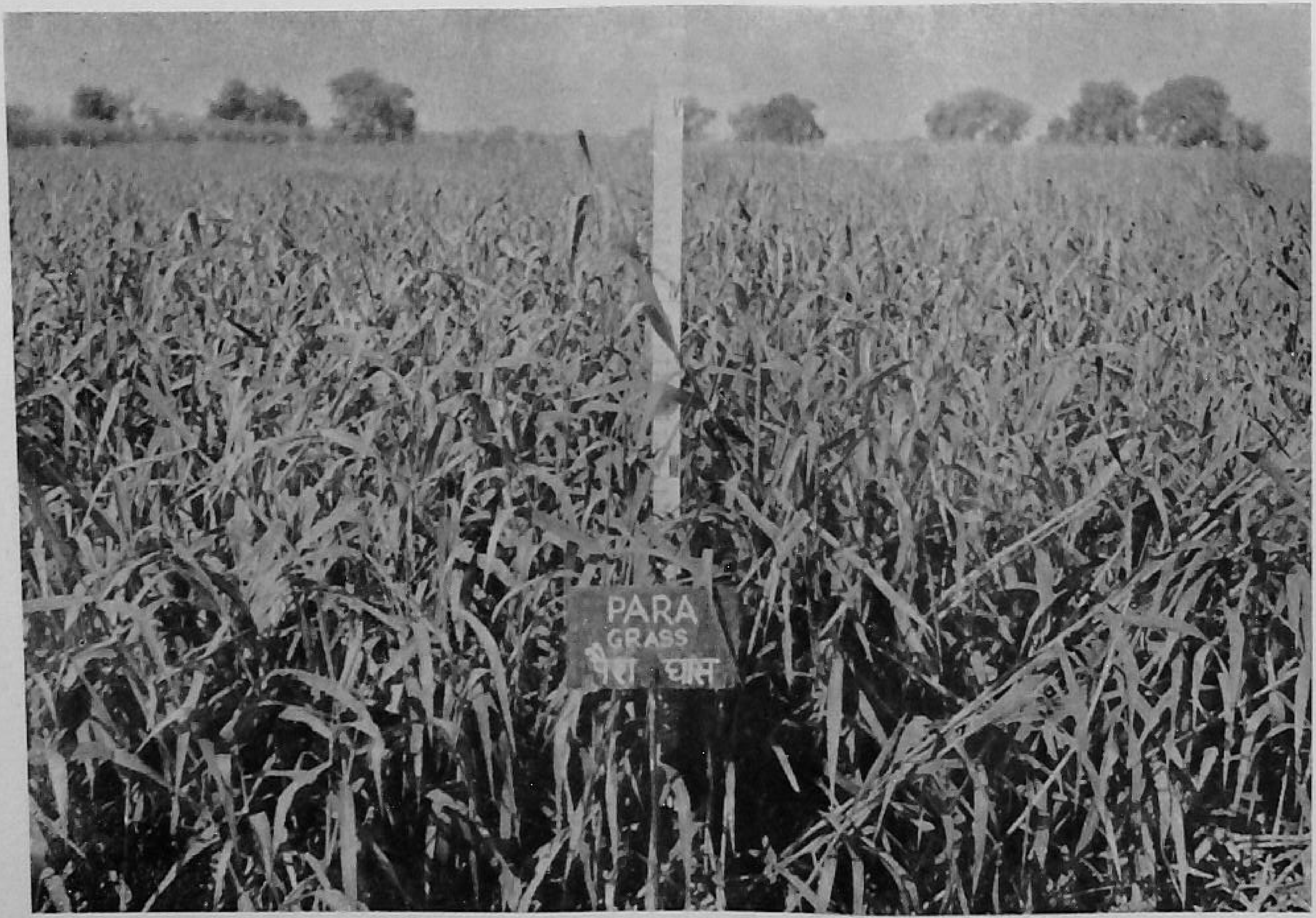
A native of South America and West Africa but now introduced in various parts of India (Assam, Bombay, South India, Delhi).

Although a native of Brazil, Para Grass has become established as an important fodder grass in many tropical countries like Ceylon, Mauritius, West Indies, Australia, Philippines and Mexico. The grass appears to have been first introduced into India at Poona in 1894. Although its initial performance at Poona was very promising, its extension to other parts of India is only a recent development. It is now regularly cultivated on an intensive scale in Aarey Milk Colony in Bombay, Quilon in Travancore, and Bangalore in Mysore.

Like other tropical grasses, Para grass is well suited to the warm and humid climate of tropical India. It thrives well in sub-tropical India, but being sensitive to cold it remains non-productive during the winter months. Although it makes fairly good growth on dry soils, its best growth is shown on moist almost water-logged soils. It grows well on the margins of ponds, tanks or on the banks of ditches and on soils too wet for the normal farm crops. It stands flooding remarkably well and makes a vigorous growth on lands that has been under water for a prolonged period. It responds excellently to irrigation with sewage or cattle shed wash.

Since seed formation is either poor or completely absent, the grass is propagated by cuttings about 12 inches long having two or three nodes. These

PLATE XXXVI



A good stand of Para grass (*Brachiaria mutica*) grown under sewage conditions

Photo : I. A. R. I.

are dibbled 2 feet apart in a well-ploughed field. For an early stand the planting is generally done at a closer distance. Rooted runners give quicker establishment than ordinary cuttings. When irrigation water is available, planting can be undertaken at any time during the year, but preferably in spring so as to give the crop the benefit of an early start.

Under rain-fed conditions, however, it would be planted after the commencement of the monsoon. The plant establishes itself quickly. In the initial stages of growth, it sends out long surface runners which root freely at the nodes. As soon as the field is completely covered, the plant sends out erect shoots which may attain a height of four or five feet. Close planting brings about the erect growth earlier than when wider planting is practised.

The crop generally becomes ready for the first cut in about three months after planting. Later, the crop can be cut once a month depending upon the climate, the frequency of irrigation, and correct manuring. The average yield in an eight-year trial at Poona between 1894 to 1902 was nearly 13 tons green fodder per acre per year, which compares favourably with yields obtained in Florida. At Coimbatore, with 40 cartloads of farmyard manure as a basal dressing and a top-dressing of 20 cartloads of compost with 100 lb. of ammonium sulphate after every second cut, an average wet yield of 25 to 30 tons per acre per year was recorded. With sewage irrigation in Bangalore, over 50 tons per acre per year have been obtained in twelve cuts, while at the Aarey Milk Colony a record yield of over 80 tons per acre per year in twelve cuts has been reached with irrigation from cattle-shed wash. These yields compare favourably with those obtained in Fiji and Hawaii. Since Para grass is liable to become sod bound, it is desirable to open up the soil at least once a year, preferably during the dormant period in cold weather.

In Guam this grass is used for reclaiming newly cleared areas, old lands and low lands. It is extensively used for planting in the coconut plantations in Panama and Guam. The grass is variously utilized in Florida and other countries as a soiling, hay and pasture crop. As a soiling crop the grass is generally cut when it attains a height of three to four feet, before it gets woody. Although the hay is rather coarse, it is considered to be of excellent quality. It can stand moderately heavy grazing and can carry one to two animals per acre for a period of nine to ten months, as has been recommended in Florida and Guam. In India, however, the grass is mainly utilized for soiling purposes. Recent trials conducted

by the I.A.R.I., New Delhi, have shown that highly saline lands can be utilized profitably by growing this grass for fodder.

The grass is very palatable and reported to be eaten by livestock with the same persistency and regularity in all stages of maturity of the plant. It contains only about five to six per cent protein; and CaO and P_2O_5 are also low at 0.76 and 0.49 per cent respectively. The nutritive value can be considerably improved by growing it mixed with velvet bean or *Centrosema*, a practice followed in Guam and Australia respectively.

The high-yielding ability of the grass and its adaptation to wet and saline soils increase the scope of its introduction and utilization in the vast marshy water-logged and saline soils of India.

Panicum maximum Jacq. Guinea grass

A perennial densely tufted grass 2 to 3 m. high. A large number of shoots arise from the short stout rhizome; culms erect, glabrous, but the nodes are densely hairy, sheaths usually densely pubescent. Ligules 4 to 6 mm. long, blades 30 to 75 cm. long, up to 3.5 cm. wide, margins scabrid, midrib prominent below, shallowly channelled above, nerves up to nine on each side. Panicles 20 to 50 cm. long, much divided, long stiff branches ascending naked at base, the lower in whorls with minutely hairy axils. Spikelets 3 to 3.3 mm. long, first glume rather short about one-third the length of spikelets. Grain over 1 mm. long.

This native of tropical Africa has spread to many countries including Australia, the Philippines and the Southern States of U.S.A. The grass appears to have been introduced into India about 1793 and is, therefore, the oldest of the introduced grasses. It is now a recognised fodder grass and is cultivated in many parts of the country.

Extensive trials have shown that the grass can be successfully grown under varied soil and climatic conditions, but not in water-logged soils or cold climates. Medium loam soils in the warmer parts of India appear to afford the optimal conditions.

Although seed formation in this grass is fairly satisfactory, the seeds do not ripen at one time and the mature seeds are immediately shed. On this account, the grass is chiefly propagated vegetatively by root stocks. The method of cultivation is rather similar to that for Napier grass, which is similarly propagated.

PLATE XXXVII

Flowering branches of the gigantic and gregarious grass '*Themeda arundinacea*' in Terai area, Uttar Pradesh

Photo : D. Chatterjee.

The *plant is lifted* and the tussock broken into individual rooted plants. Since the grass forms a large clump, a distance of three feet on either side is usually favoured. The field is irrigated immediately after planting. Subsequent irrigations are given as and when required. One or two inter-cultivations are necessary during the establishment period.

The best time for planting under irrigation is from mid-February onwards, but under rain-fed conditions planting immediately after the outbreak of monsoon is practised.

The first cut is generally obtained two and a half months after planting, and the grass can then be cut at intervals of six to eight weeks depending upon the soil fertility, irrigation and manuring. Average yields vary from 15 to 25 tons. In early trials at Karachi the grass grown under raw sewage gave a record yield of 90 tons per acre in eight cuts. At the Sewage Farm, Madura, in Madras State, wet yields of over 100 tons have been recorded. Similarly, yields of 53 tons per acre in twelve cuts have been recorded in North India. For good yields, an application of 10 to 15 cartloads of farmyard manure per acre before the rains or a top-dressing of at least five tons per acre of well-rotted manure after every fourth cut have been recommended in Bombay State; in Madras it is recommended to apply 40 carloads of farmyard manure as a basal dressing, with a top-dressing of 20 cartloads of compost and 100 lb. of sulphate of ammonia after every two cuts.

Yields fall with age so that fields should be replanted after every three to five years. Replanting may be done between the rows in a standing field of Guinea grass, removing the old plants after the new ones are firmly established, so that a uniform flow of fodder is maintained.

The grass is utilized mainly as a soiling crop in India, although it has been grazed successfully at a few places. It can be grown with advantage along water channels, to protect the *bunds* against erosion or infestation of weeds. In Western India, it has been recorded as growing luxuriantly under the shade of mango trees. The grass makes a fine hay and can also be used for silage.

Guinea grass is palatable to all classes of livestock. It is superior to Napier grass in quality, and compares favourably with *juar* and maize fodder. It is best utilized if cut when about three feet in height. Unlike Napier grass, it does not become coarse even if allowed to grow further, but it is apt to lose some

of its palatability with age. The grass is fairly nutritious, and contains an average of five to eight per cent protein; calcium and phosphorus contents are fairly well-balanced.

Pennisetum purpureum Schum. Napier grass; Elephant grass

A robust perennial grass with creeping rhizome, culms 2 to 4 m. tall, 1.2 to 2.5 cm. in diameter, obliquely erect, round, more or less glabrous. Leaf blade 30 to 60 cm. (rarely 90 cm.) long with a strong mid-rib, dull green, sometimes glaucous, or purplish. Ligule a narrow rim of small white hairs. Inflorescence a dense erect spike 8 to 20 (rarely 30) cm. long, 1.5 to 3 cm. in diameter, yellow, brown or purple, of deciduous spikelets. Each spikelet surrounded by an nvolucre of bristles of varying lengths, usually 5 to 8 mm. long with one very much longer (1.2 to 2 cm.).

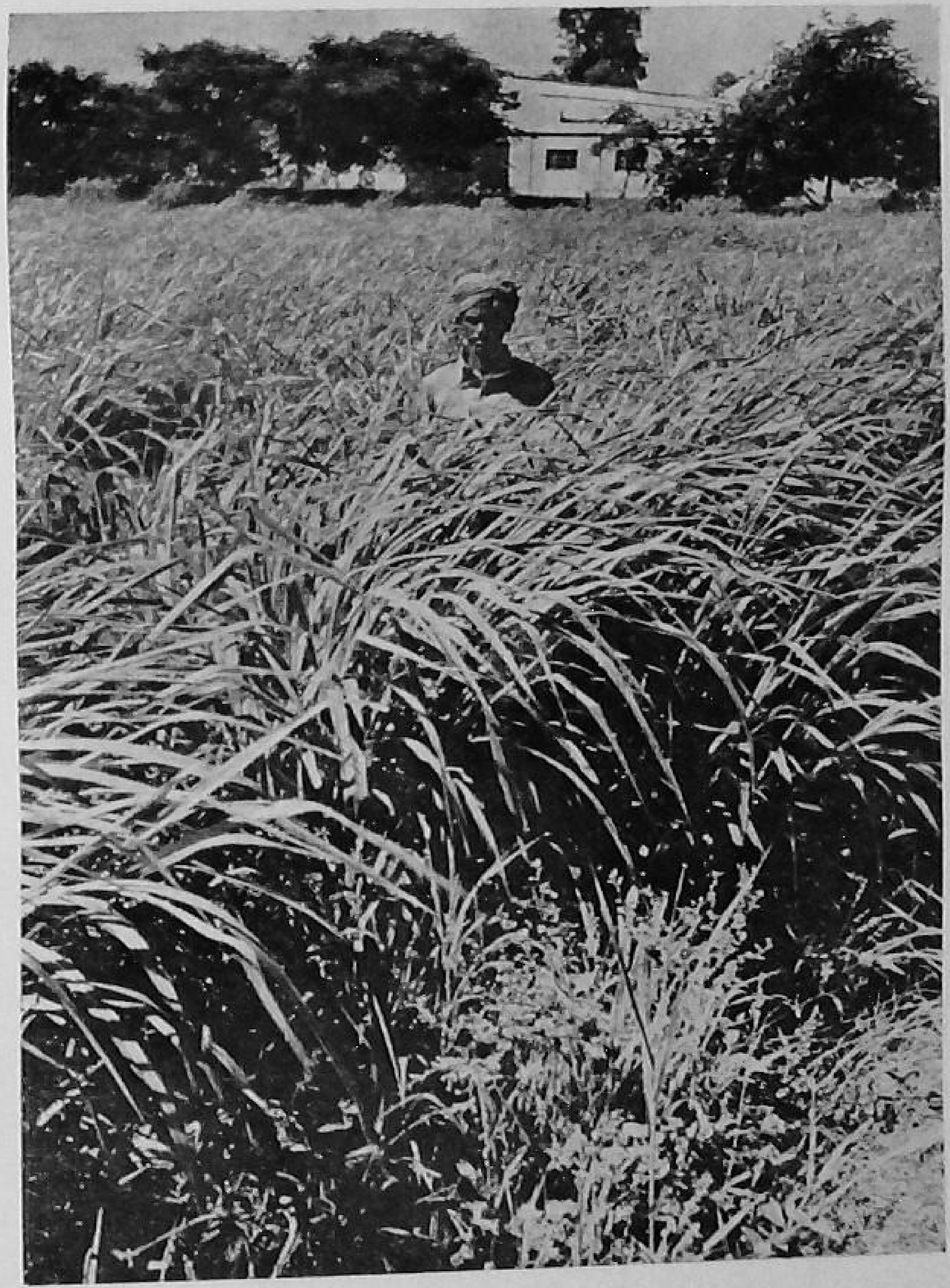
Napier grass owes its name to Col. Napier of Bulawayo, who in 1909 drew the attention of the Agricultural Department of Rhodesia to its value as a fodder plant. The grass was first described in tropical Africa where it is common between latitudes 10°N and 20°S, more especially in marshy localities and in open bush and forests. It occurs gregariously in the delta area of the Zambesi and forms reed jungle. It is also found in hills between 2500 feet to 5000 feet.

The grass was first grown as a crop in Transvaal and Rhodesia in 1910, taken to America in 1913, and later to Australia and other countries. It was introduced into India around 1912-15 and now is cultivated as a fodder crop for soiling purposes in Assam, Bengal, Bihar, Orissa, Uttar Pradesh and Punjab and to a lesser extent in Madhya Pradesh, Madras, Mysore and Bombay.

Napier grass is adapted to warm and humid climates and fertile loamy soils. The grass is propagated vegetatively by the planting of canes or rooted stocks. Cuttings with at least two nodes with buds are planted on well-prepared land with adequate moisture, like the setts of sugarcane, in furrows three feet apart; the first irrigation is given only after sprouting is completed. Subsequent irrigations are given when necessary, depending upon the season. Alternatively the cuttings are struck in the soil at an angle of 46°, in such a way that one bud remains above ground and the other is buried in the soil. The land is then irrigated immediately after planting.

Propagation by dibbling rooted stocks in well-prepared soils is, however, a

PLATE XXXVIII



Napier grass (*Pennisetum purpureum*) at Nagla Dairy, Terai State Farm, Uttar Pradesh

Photo: D. Chatterjee

more successful method; the distance ween rows and plant to plant is three feet. At this rate, about 5000 cuttings or root stocks are required per acre.

The best planting time under irrigation is from mid-February onwards, but where winters are milder planting can be done almost any time during the year. Under rain-fed conditions, however, the grass is planted after the monsoon has begun.

The first cut is generally obtained about three months after planting, and subsequent cuts every six to eight weeks under proper management. An average yield of 30 to 35 wet tons per acre is common, but under favourable conditions yields of over 50 tons in five or six cuts have been obtained in Uttar Pradesh, Assam, and Madras. Bangalore has recorded an yield of 85 to 87 tons per acre. With sewage irrigation high yields are obtained without additional manuring.

As the grass is a heavy yielder, it shows a ready response to manuring. It is profitable to apply ten to fifteen cartloads of farmyard manure per acre at initial planting, followed by annual top-dressings of 200 lb. of ammonium sulphate, preferably in two lots of 100 lb. each, during the winter and when the monsoon breaks.

Once established, Napier grass continues to give fodder for a number of years but with age the productivity goes down, and it becomes economic to replant it every five or six years.

The grass is cultivated in India mainly as a cut fodder. It is also an excellent crop for silage. The grass remains green on dry land late into the autumn and withstands frost to a remarkable degree. It is considered equal to bamboo for paper making.

As a fodder it is rather coarse and is considered inferior in palatability to green maize, green *juar*, Sudan and Guinea grass. It is best utilized if cut when the plants are four feet high; if allowed to grow taller, it becomes fibrous and loses its palatability. It is fairly nutritious, containing five to seven per cent protein. The calcium and phosphorus contents are fairly well-balanced, but, like other species of *Pennisetum*, the phosphorus content is sometimes the higher. Research in Ceylon and Uganda shows that the grass leaves the soil in better condition with respect to organic matter, nitrogen content and soil structure. It has been adopted in rotations for soil restoration in Uganda, three years grass followed by three years of cropping.

Chloris gayana Kunth Rhodes grass

A perennial grass. Culms 1 to 1.5 m. tall with strong leafy stolons. Internodes three to nine compressed below, sheaths glabrous or sparingly hairy near the mouth; leaf-blade linear long-tapering 15 to 30 cm. long, 3 to 5 mm. wide, green, smooth below, rough above on the margins. Spikes 6 to 15, digitate, sub-erect, 5 to 10 cm. long, spikelets crowded, pale-brown, 3 mm. long, three to four flowered, shortly two awned, awns 1 to 5 mm long.

The grass is indigenous to South and tropical Africa; it was introduced into cultivation by late Mr Cecil Rhodes in his estate near Capetown and rapidly became popular as a useful fodder grass. It was introduced into America in 1902 and spread to Australia and other countries. It appears to have been introduced in India about the year 1915 at Bangalore Military Dairy Farm, and has since spread considerably. Trials conducted in various parts of the country have led to its recognition as an important addition to the fodder grasses of India. As it is both drought-resistant and sufficiently winter-hardy to withstand low temperature even a few degrees below freezing point, Rhodes grass is adapted to both tropical and sub-tropical India.

Rhodes grass grows well on all except stiff clay black cotton soils or soils subject to water-logging. Its best performance is on sandy loams. It grows fairly well on saline soils and appears to be suited to black alkaline soils, as reported from Arizona. Being a drought-resistant grass, it grows fairly well under purely rain-fed conditions, but responds well to irrigation. It can be established by seeds and vegetatively by rooted cuttings. The sowing or planting can be done at any time during the year, preferably in the spring if irrigation water is available. If, however, the crop is to be grown under rain-fed conditions, sowing or planting is done at the commencement of the monsoon. When the crop is to be established by seed, the seeds are broadcast at the rate of 5 to 10 lb. per acre on a finely prepared seed bed with adequate moisture. A lever or brush harrow should be worked after sowing. The seedlings appear from seven to fifteen days after sowing. When propagated vegetatively, the rooted cuttings are planted at a distance of two feet each way, or 10,000 cuttings per acre. Irrigation immediately after planting is necessary for thorough establishment.

In the initial growth period, the plant sends out surface runners in all directions, which root at the nodes wherever they come in contact with moist soil.

PLATE XXXIX

Chloris gayana

Photo : D. Chatterjee

The grass becomes ready for the first cut in about two months after planting and about three months after sowing. Subsequent cuts can be obtained more or less regularly at 30 day intervals.

In sub-tropical parts of India, seven or eight cuts of green fodder are obtained in a year, while in warmer regions of Southern India as many as twelve cuts have been recorded. The grass is a fairly heavy yielder, giving an average outturn of 15 wet tons per acre. It responds quickly to manuring; a basal dose of about ten tons farmyard manure per acre has been recommended. An application of two and a half maunds of sulphate of ammonia in combination with an equal quantity of superphosphate, or of five maunds of ammonium phosphate per acre is advantageous. From lands irrigated with sullage water and drainage from cattle stalls, a record yield of 97 tons of green fodder per acre in ten cuts is recorded from Bangalore.

In order to maintain the stand, the grass should be irrigated after every cutting, in addition to regular irrigations at intervals of 10 to 15 days depending upon the season. Opening up of the soil after every cut has also been recommended.

For harvesting the seed, the crop should not be cut after the end of July; the seed crop matures by October/November. Seed collection becomes difficult owing to lack of uniformity in the seed development; since, however, the mature seeds are retained for a reasonable period, bulk harvesting of seed is made possible. The best but more expensive method is by hand picking. Exact information on seed production is not available, but about 100 lb. per acre of unhusked seed may be obtained.

Athough Rhodes grass is suitable as a pasture, hay and soiling crop, it is like all other introduced grasses used mainly as a soiling crop in India. For this purpose the grass is generally cut just before flowering. As a pasture crop, it is grazed at the rate of two steers per acre for a period of 10 months, as reported from Florida and Texas. Rotational grazing has been recommended as the best method of management. Rhodes grass yields about five to seven tons of hay per acre. At Bangalore, Rhodes grass is used as a pasture crop and is grazed till September, the aftermath generally being reserved for hay. The grass has been considered in Australia as a useful crop in rotation with cotton. It can be grown successfully with lucerne, to maintain continuity of fodder supply during summer

and winter months, as observed at Delhi. A three-years stand of this mixture showed beneficial residual response on unmanured wheat/maize in a three-year rotation.

The grass is very leafy and palatable. Home and Draper, who first introduced it into India, comment. "Horses and cattle eat it with relish and the grass, though its stems are succulent, does not contain an unduly large proportion of moisture even during the rainy season, or when grown on irrigated land." In the West Indies the grass is considered to improve the health of poor animals. In Australia it is considered to be more nutritious than *Paspalum dilatatum*. Chemical analysis showed on a dry matter basis a protein content of 5.0 per cent with about 0.5 and 0.4 per cent of CaO and P_2O_5 respectively.

Although, like other introduced grasses, the cultivation of Rhodes grass is restricted at present to Government Farms, there has in recent years been a fair demand from cultivators in North India. Its successful establishment on saline soils extends the possibility of its profitable introduction to these areas of the country.

Panicum antidotale Retz Blue Panic Local names : *Git, Ghamar, Barwari*

A tall perennial grass reaching a height of 1.5 m. Rootstock creeping, stoloniferous, culms solid smooth, with thickened nodes. Leaves 15 to 60 cm. wide, linear, tip drawn out to a fine point. Sheath long, glabrous, ligule short, membranous or fimbriate. Panicle 15 to 23 cm. long, pyramidal, lax, branches fascicled, slender, filiform, spreading and drooping. Spikelets laxly crowded on the branchlets, 3 mm. long, ovoid, acute, glabrous, strongly nerved.

This drought-resistant grass is originally a native of Northern India. Although fairly well-distributed in Australia, Afghanistan, Ceylon and India, its agricultural value was first noted in Australia. It was first tried in India at Coimbatore in 1938, with seed imported from Australia; since then, trials in many parts of the country have shown it to be a useful introduction in semi-arid regions.

The grass is adapted to a variety of soil and climatic conditions. It does well in semi-arid regions where the annual rainfall does not exceed 25 inches. Being both drought-resistant and winter-hardy, the grass appears to succeed in both Southern and Northern India. It does not appear to be very exacting in its soil requirements, growing equally well on light and heavy soils of low to high

PLATE XL

Panicum antidotale (Karnal Strain)

Photo : I. A. R. I.

fertility. Optimal performance is on moist fertile sandy loam soils. Its adaptability also ranges from alkaline to acid soils.

Since the grass produces an abundant quantity of good seeds, it is mainly propagated in this way. Seeds are broadcast or drilled at 4 to 6 lb. per acre on a well-prepared seed bed, at the commencement of monsoon under rain-fed conditions or during spring if irrigation is available. Sowing in rows is preferable to facilitate interculture, which appears to be essential. The seeds germinate about one week after sowing and the crop is ready for harvesting in about three months. Under rain-fed conditions, the grass generally gives four to six cuts in a year, yielding seven to 15 tons green fodder per acre. If properly irrigated and adequately manured, frequent cuts at intervals of 12 to 15 days may be taken, the recovery after each cut being remarkable. It responds quickly to manuring; with sewage irrigation, over 50 tons per acre have been recorded.

Blue panic has been recommended for feeding green. For best utilization, the grass is cut when tender, as it has a tendency to become woody and unpalatable. Since the grass has such remarkable powers of recovery, it should be excellent for grazing purposes. The quality of its hay has been commended in Madras State.

The grass is palatable to all types of animals, but is avoided in the mature state, as the culms become very hard and woody. The grass contains 7.5 per cent protein and the CaO and P_2O_5 contents are well-balanced, being 0.9 per cent in each case. The nutritive quality of the hay is maintained at a high level.

There is considerable scope for extending the cultivation of this grass, particularly in the semi-arid regions of Southern India. Blue panic has a further good quality of keeping green throughout the winter; the area of its cultivation can, therefore, be increased in Northern India, where the winters are rather severe. Cultivation under irrigation with or without addition of sewage is also desirable.

Sorghum sudanense Stapf Sudan grass

Annual grass 2 to 3 m. tall. Leaf blades 15 to 30 cm. long, 8 to 12 mm. wide. Panicle erect loose, 15 to 30 cm. long. Sessile spikelets 6 to 7 mm. long, lanceolate ovate with a ring of hairs at base; awns persistent, 10 to 15 mm. long, twisted below. Pedicellate spikelet narrow, 6 to 7 mm. long, strongly nerved.

Sudan grass is commonly found in the arid regions between Algeria and Senegal in North Africa; its value was first noted in the Sudan. It does not have the

aggressive underground stems of Johnson grass (*Sorghum halepense*). The seed was originally brought to the Sudan from Egypt where it is stated to have been under regular cultivation. It was first tried in New South Wales in 1913. Trials in India are reported first in Assam in about 1920, in Bombay State about 1925, and in Punjab in 1930.

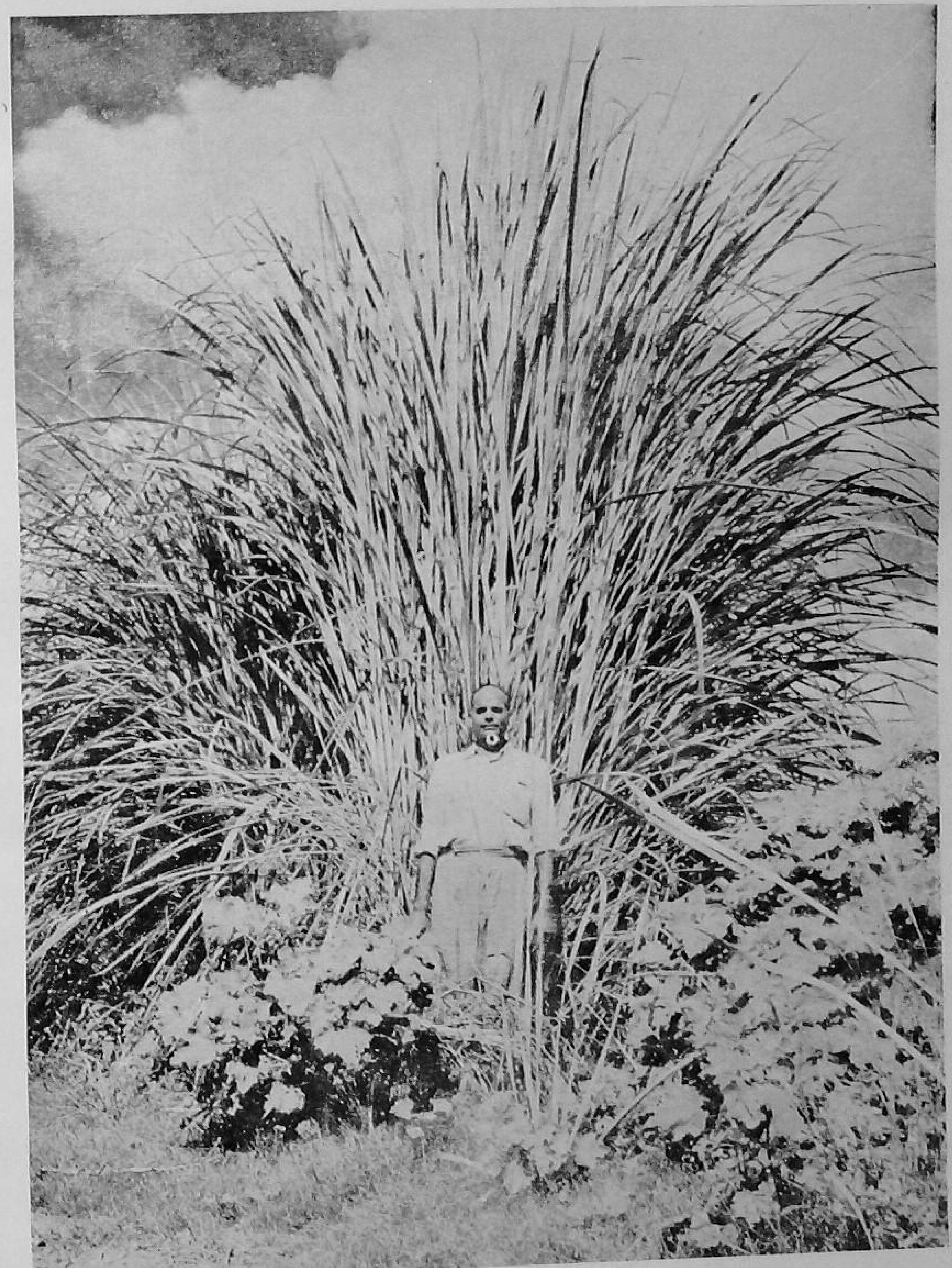
The grass is adapted to warmer regions where conditions favour the cultivation of *juar*; like *juar* it does not thrive in high altitudes or in wet and alkaline soils. Being drought-resistant, it can be grown as a dry or irrigated crop. It can be sown from March onwards under irrigation or after the commencement of the monsoon as a rain-fed crop. The grass is established from seeds, which are broadcast or drilled in close rows about nine to twelve inches apart on a well-prepared seedbed at 16 to 24 lb. per acre. When drilled, the seeds are sown at a depth of one to one and a half inches.

Sudan grass grows quickly, and the first cut is generally taken in seven to ten weeks after sowing, subsequent cuts at intervals of six weeks; yields are about 15 to 20 tons of green fodder in about four cuts but yields as high as 26 tons have been obtained under favourable conditions. These compare favourably with those obtained in U.S.A. and other countries. The grass responds well to manuring and 20 to 30 tons of farmyard manure are recommended as a basal dressing.

Sudan grass produces seed freely in a loose open panicle. As it crosses freely with other sorghums, it is necessary to cultivate it for seed at a distance from other sorghum fields; it is preferable to keep the ratoon crop for harvesting seed in April and May when no other sorghum is in flower. The crop is harvested and stacked in small bundles from which earheads are threshed for seed when dry. Since new earheads are given out throughout the growing season, the panicles alone can be collected when they become ripe. Under favourable conditions about 250 to 400 lb. per acre of good seed can be obtained.

The grass is utilized as a soiling, hay, silage or pasture crop. As a soiling crop it is generally cut at the time of flowering, but it is recommended in Australia that it should never be cut below a height of three feet, owing to the high percentage of hydrocyanic acid in the early stages. A crop which is stunted due to drought should for the same reason not be fed to stock; this difficulty can be overcome by irrigating the crop during drought periods. The quality and quantity of the fodder may be improved by growing the grass in mixtures with legumes such as cowpeas, soybeans, velvet beans or cluster beans (*guar*).

PLATE XLI



A typical tussock of *Themeda arundinacea* in Terai area, Uttar Pradesh. Other plants in the foreground represent the well-known and troublesome weed, *Xanthium strumarium*

Photo : D. Chatterjee

Because of the thin-stemmed nature of the grass compared to cultivated sorghums, it is admirably suited for utilization as a hay crop. Three to four tons of hay are normally obtained from an acre. As a silage crop, it does not compare favourably with either *juar* or maize. Sudan grass has become popular as summer pasture in U.S.A. and Australia, where it is grazed when the crop is one and a half to two feet high.

The slender leafy stems of Sudan grass are palatable to cattle, horses and sheep alike. The feeding value of Sudan grass hay is practically equal to that of millet and other non-leguminous roughages. The protein content is about 6 per cent and CaO and P_2O_5 are well-balanced.

Cynodon plectostachyon Pilger Giant star grass

Extensive perennial grass with runners covering long distances. It resembles strongly the allied grass *Doob* (*Cynodon dactylon* Pers.) from which it can be distinguished by it its larger size, more vigorous growth and larger digitate spikes.

Giant star grass was first collected in 1938 in East Africa. Regular trials were started in 1940 at Coimbatore with seeds obtained from South Africa. At about the same time the grass was established at the Vivekananda Laboratory at Almora. The grass has since become well-known in India. Giant star grass is a dense perennial grass with an extensive network of runners, some of which measure more than 50 feet. The dense erect growth often reaches a height of three to four feet. The grass spreads quickly, as it roots freely at all nodes.

Giant star grass is adapted to all soils. It establishes well under irrigated and rain-fed conditions. It thrives well on the plains and in the hills, under annual rainfalls varying from 20 to 105 inches. It is usually not manured. Although the grass can be established from seeds, it is generally propagated by cuttings and root stocks or slips. The slips are planted on a well-prepared seed bed one and a half feet apart either way. As a rain-fed crop it is planted at the commencement of the monsoon rains, but as an irrigated crop it can be planted at any time of the year.

The first cut is ready after three and a half months and subsequent cuttings are taken at intervals of about two months. Yields under dry conditions are from

15 to 30 tons of green fodder per acre in three to four cuts. In Almora, an yield of more than 25 tons of green fodder per acre is reported.

The grass is mainly used as pasture but may also be cut and fed as green fodder or made into hay. Chemical analyses conducted at Coimbatore, Izatnagar and I.A.R.I., New Delhi, showed the presence of HCN in negligible quantities. Feeding trials carried out at Coimbatore and Izatnagar proved that hydrocyanic acid is not present in quantities likely to be dangerous to animals. As the HCN content decreases with age, hay made of mature grass contains negligible amounts. It contains 10 per cent protein and is also rich in CaO and P_2O_5 (0.8 and 0.5 per cent respectively). The grass is valuable for soil conservation purposes; in Madras State, it is used on railway embankments and on the earthen dam at Bhavani Sagar. This grass has promise for Northern and Southern India, as a soiling crop, pasture grass and for erosion control.

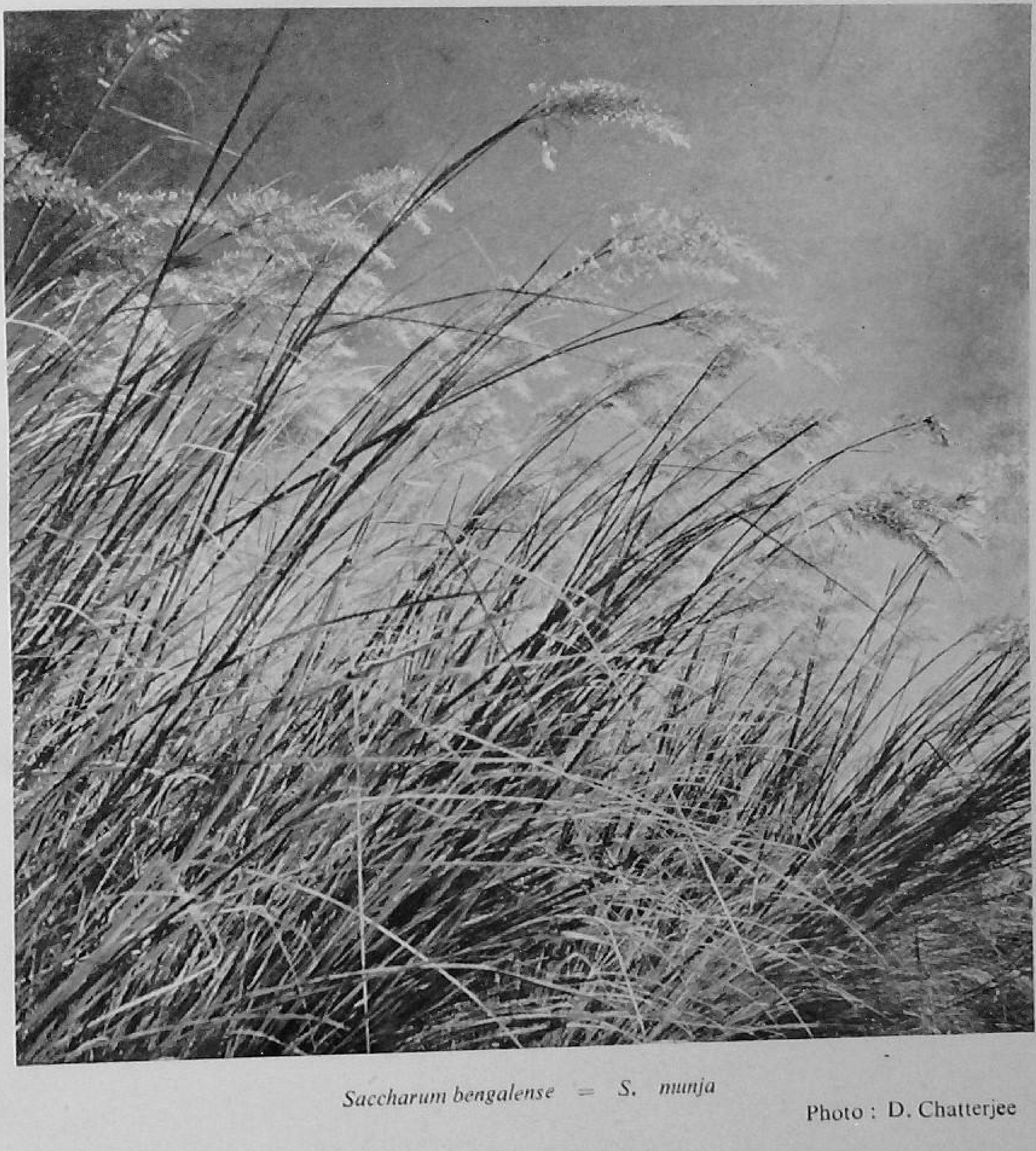
Euchlaena mexicana Schrad. Teosinte

A tall, annual, succulent grass resembling the maize plant, 2 to 3 m. (rarely 5 m.) tall. Leaves very long and as much as 7.5 cm. broad. Culms branching at base. Male inflorescence terminal as in maize, 15 to 25 cm. long. Female spikes lateral in the axil of leaves, sunken in cavities of an obliquely articulated rachis which is covered in a number of foliaceous spathes.

Teosinte, a close relative of cultivated maize, has been said to be indigenous to Mexico or Central America. It was introduced into India at Poona in the year 1893, and to Assam in 1911. In the Punjab it appears to have been introduced in the early thirties and has become quite popular with the cultivators.

It is essentially an annual tropical grass adapted to warm regions with high humidity and heavy rainfall. It is exacting in its soil requirements, showing optimum performance on rich loamy and well-drained soils, but can be cultivated in poor, sandy and gravel soils with adequate manuring. It is sown as a monsoon crop on a thoroughly prepared seedbed after the outbreak of the monsoon or as an early fodder crop in the month of April, under irrigation. The seed is broadcast or drilled at 25 to 30 lb. per acre, but in Bombay State a seed rate as low as 10 to 15 lb. per acre has been recommended. As its water requirement is slightly higher than maize, the crop needs to be irrigated quite frequently if rainfall is not adequate; three or four irrigations are generally considered to be sufficient.

Plate XLII



Saccharum bengalense = *S. munja*

Photo : D. Chatterjee

The plant tillers profusely forming a thick clump, and may under favourable conditions reach a height of over ten feet. The crop is ready for cutting three to three and a half months after sowing. If a long stubble is left, it gives a second cut in about seven weeks time. From an early-sown crop three cuttings are generally available.

It is a fairly heavy yielder, giving an average of 15 tons per acre, but yields of over 22 tons have been recorded in Assam. In the West Indies, yields average 12 tons per acre while in the Philippines 27 tons have been reported. The highest yields of over 56 tons per acre have been recorded in Louisiana Under rain-fed conditions, a yield of seven to ten tons has been obtained. Applications of 10 to 15 tons of farmyard manure or two maunds of sulphate of ammonia per acre have been recommended in the Punjab.

A seed crop may be harvested in November. If allowed to dry for a week before threshing, a good crop may give up to 1,200 lb. of seed per acre.

Teosinte is utilized mainly as a cut fodder, though from Assam and the Punjab it is reported as a hay and silage crop. In the Punjab, the fodder is considered to be succulent and nutritious and palatable to all kinds of cattle. The crop has been recommended for cultivation to fill the gap in green fodder supply during the summer months, sown either pure or with velvet beans and soybean. Trials conducted at Poona by Mollison and later workers led to the conclusion that the grass is not suitable for feeding as it is coarse and adversely affects the milk yield when used as a substitute for maize.

The protein content is about 5 per cent ; it is rich in calcium but rather low in P_2O_5 content.

Eragrostis curvula (Shred.) Nees Weeping love grass

A densely tufted tall erect grass. Sheaths narrow, glabrous or thinly hairy except the lower part which is densely hairy. Leaf blades elongate, apex drawn to a fine point. Panicles 20 to 30 cm. long, branches solitary or in pairs, ascending, densely and minutely hairy at base. Spikelets seven to eleven flowered, 1 to 10 mm. long, lemmas about 2.5 mm. long with prominent nerves.

This grass can be established in Northern India; its rather low palatability makes it of value more particularly for soil conservation.

Pennisetum clandestinum Hochst. ex Chiov. Kikuyu grass

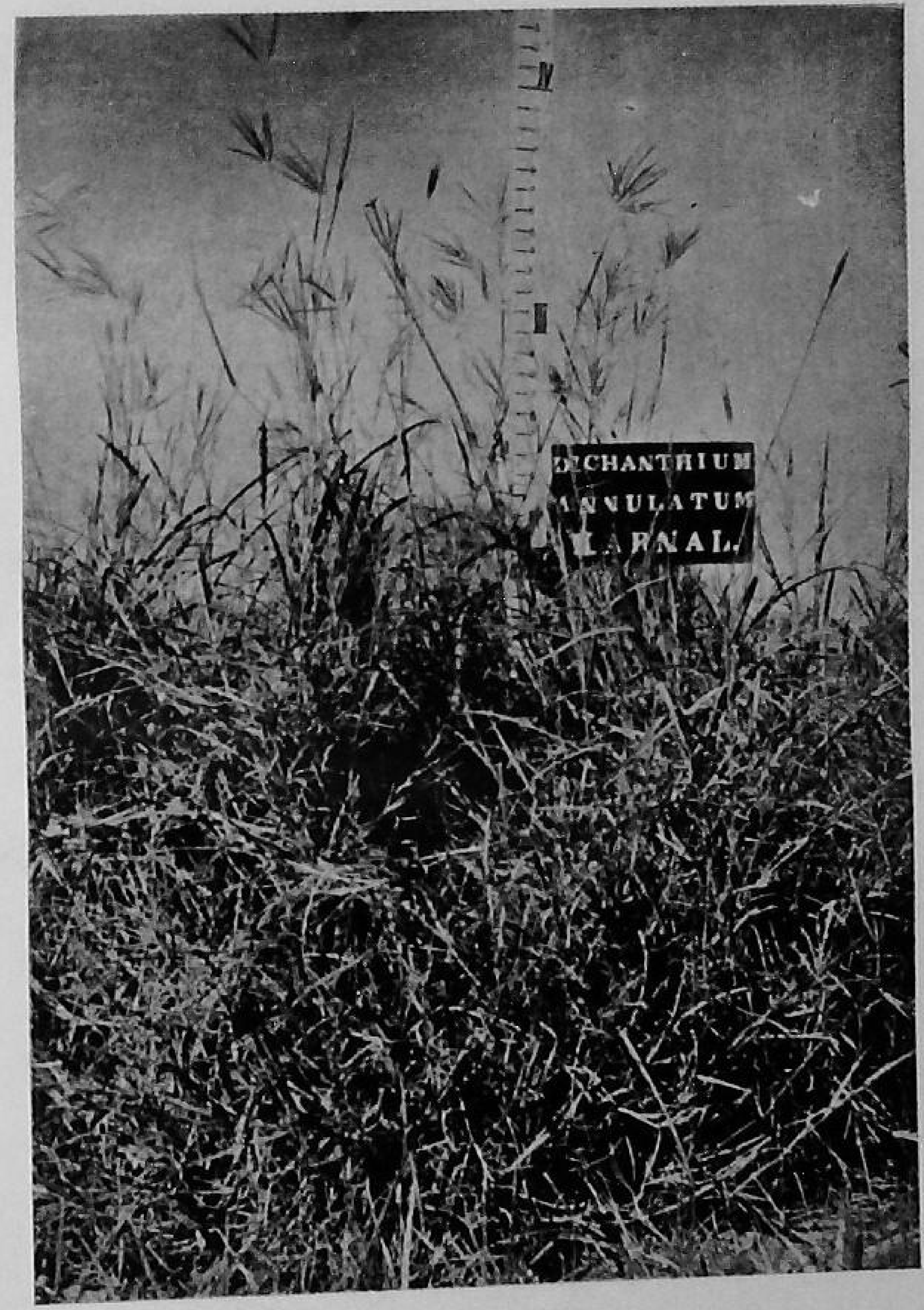
This is a rhizomatous, stoloniferous perennial grass. Stolons have short internodes which help in forming dense growth and coverage. Leaf-blade 1.2 to 5 cm. long, flat, linear, glabrous or slightly hairy ; mid-rib prominent below. sheath closely imbricate. Ligule reduced to a densely hairy rim. Inflorescence of only two to four spikelets and almost enclosed in the uppermost leaf sheath. Spikelets surrounded by an involucre of short bristles. Stamens with long filaments (2.2 cm. long), style thread-like, 3 cm. long, simple or bifid and finely plumose.

Kikuyu grass was introduced into cultivation in South Africa in 1910, into Australia in 1919, into North-West Frontier Province of undivided India and in 1921 from Austıalia to the Wellington Military Farm in the Nilgiris. The grass is particularly suitable for moist hilly situations of India, thriving best on rich loamy soils at an altitude of 4,000 feet or more. Its performance has not been satisfactory in the plains as it is susceptible to frost ; it remains dormant during the winter, putting forth fresh growth with the commencement of spring.

Since seed formation is rare in nature, the grass is propagated by rootstocks or runners which may be planted fairly wide apart, three feet between plants and rows. Although Kikuyu is a hardy and vigorous grass, it is always advisable to plant it on a well-prepared field so as to ensure rapid and successful establishment. Being a summer grass, the best time of planting is during the spring or after the commencement of the rains. The grass spreads vigorously by both surface and underground runners and covers the soil completely in a single season. Its top growth which attains a height of two and a half to three feet, is obtained within about three to three and a half months. Later cuttings can be taken at about 40 day intervals (Wellington, Nilgiris) giving a total yield of about 15 tons per acre per year. Kikuyu responds generally to manure, which is best applied before the onset of the monsoon.

With the dense and rapid growth combined with hardiness and persistency, Kikuyu is considered primarily as a pasture grass. Dairy cattle are regularly allowed to graze on Kikuyu pasture at Shillong (Assam), but in the Nilgiris it is also used for soiling purposes. It is very palatable to all kinds of stock. Analyses in South Africa and Australia show a high protein content of about 12 per cent with an albuminoid ratio of 1:3.5; it is, therefore, eminently suitable for milch cattle.

PLATE XLIII



Dichanthium annulatum (Karnal strain)

Photo : I. A. R. I.

Its creeping habit and aggressive growth make the grass valuable for soil conservation. In the country of its origin, it has been recommended for planting in poultry runs; fowls like the leaves; its aggressive nature helps it to withstand their scratching. The grass also makes an excellent lawn, the bright light green colour of foliage forming an excellent setting for ornamental gardening: it also makes an excellent field lawn as it forms a dense soft and springy turf when closely grazed or clipped.

Kikuyu grass appears to have good possibilities for introduction in the hilly humid areas at higher altitudes of 4,000 ft. and above, for improvement of hill pastures and conservation of soil on the slopes.

Indigenous Grasses

Dichanthium annulatum Stapf Local names : *Jarga, bara jergi, marvel, palwan, Zinzvo.*

A perennial tufted grass with creeping rhizomatous stem. Branches erect or abruptly ascending from the creeping stem, about 1 m. tall, smooth and glabrous. except at the nodes which are purplish and bearded. Internodes compressed, grooved on the surface corresponding to the back of the sheath; and pale purplish in colour. Leaves 7.5 to 30 cm. long, 3 to 6 mm. wide, somewhat waxy, and thinly hairy with minute tubercles at the base of hairs of upper surface. Leaf sheath glabrous, sometimes with minute hairs on the margin. Ligule short, oblong, obtuse, membranous, glabrous or ciliate.

Inflorescence consists of a number of racemes which are attached more or less to the apex of the axis. Racemes 2.5 to 7 cm. long, usually purplish in colour.

The species strongly resembles *Bothriochloa pertusa*, from which it can be distinguished by the absence of pits in the lower glumes. This grass is considered to be one of the best fodder grasses and is very common in pasture lands in 'Northern India.'

It was introduced from India to the Angleton, Experimental Station, Texas, in 1915, and proved to be a desirable grass, although a poor seeder. It is particularly adapted to the heavy clay soils of the Gulf Coast prairie, where the rainfall exceeds 30 inches. Plantings on the black land at Waco, Texas, have shown promise, and it has been grown successfully at Lubbock and Chillicothe, Texas, and under irrigation west of this region. It does well on sandy loam soils, but is best

adapted to well-drained soils. It may be planted by sprigs or rooted runners, and should not be grazed until well-established. It has a low chemical analysis except in the young stage. Hay yields are two to six tons per acre. This grass does not fit well in mixtures, as it crowds out all other vegetation,

Dichanthium caricosum A. Camus Local names : *Kartak, Khel*

This species is very similar to *Dichanthium annulatum* but less common. It is found in rather dry and sandy areas.

Sehima nervosum Stapf Local names : *Pavna, Suckal, Sheda*

A perennial tufted grass growing up to 90 cm. in height. Branches erect about four-noded, the upper two are exserted. Leaves 20 to 40 cm. long, two to 5 cm. wide, sheath tight, thinly hairy from tubercled based hairs; ligule a line of stiff hairs. Leaf-blade long drawn to a setaceous point. Racemes solitary, 7.5 to 11.5 cm. long, erect or gently bent. Sessile spikelets lanceolate-linear. Both sessile and pedicelled spikelets are awned. Awns slender and twisted at the base.

Chrysopogon montanus Trin. Local names : *Goria, Guria*

A perennial grass growing in tufts. Culms slender, straw coloured, 30 to 110 cm. high, glabrous; lower leaves up to 42 cm. long linear acuminate, with scabrid margin. Upper leaves short, 8 to 10 cm. long. Leaf-sheath glabrous, markedly keeled. Ligule, a row of hairs. Panicles ovate, 3 to 12 cm. long, branches whorled, rays few to many yellowish or purplish in colour with few to several whorls of flexuous branches with groups of spikelets at their apices. Spikelets in groups of three, one sessile bisexual awned spikelet in the centre with two lateral unawned pedicelled spikelets.

Pennisetum ciliare (L.) Link (Syn. *Cenchrus ciliaris* L.) Local names : *Anjan, Charwa*

A perennial tufted grass. Culms several, erect or gently bent from the rootstock, 15 to 45 cm. tall. Leaf blades linear, drawn to fine point, 10 to 25 cm. long, 3 to 6 mm. wide, glabrous or hairy; sheaths smooth or hairy near collar, ligule narrow, ciliate, membranous. Inflorescence a dense cylindric raceme, 2.5 to 10 cm. long, 8 to 13 mm. wide, pale or purplish, rachis rough. Spikelets seated in bristly involucels. Bristles of involucre spreading.

An excellent fodder grass which is highly nutritious before flowering.

PLATE XLIV

Cenchrus ciliaris

Photo : D. Chatterjee

Cynodon dactylon Pers. Bermuda grass. Local name : *Doob*

Perennial grass creeping extensively by stoloniferous stems. Culms variable from a few to 20 cm. tall. Leaves short narrowly linear or lanceolate, soft, long acuminate blades flat, glaucous. Ligule a conspicuous ring of white hairs. Spikes usually two to eight digitately arranged on the summit of the erect peduncle. Spikes 2.5 to 5 cm. long; spikelets one flowered, awnless, latterally compressed, sessile, arranged on one side of the rachis, 3 mm. long, lemma boat shaped, acute, palea linear oblong, obtuse, two nerved.

One of the best fodder grasses and a good sand binder.

Iseilema laxum Hack. Local names : *Masel, Shata*

A perennial grass with stout rootstock. Culms several, arising from rootstock, erect or ascending, simple or sometimes branched. Leaves linear, obtuse, glabrous or slightly hairy near the base, 7.5. to 15 cm. long, 1 to 3 mm. wide; margin scabrid; ligule short truncate, membranous, ciliate. Inflorescence a panicle, 5 to 25 cm. long, raceme-like, with groups of spikelets seated on pedicels in boat-shaped bracts. The group of spikelets consists of a whorl of four male spikelets, one or more awned sessile bisexual spikelets, and several pedicelled male spikelets.

One of the best Indian fodder grasses.

Bothriochloa pertusa A. Camus Local names : *Jarewa, Choti jergi*

A perennial grass with erect or ascending culms. Nodes bearded with spreading hairs, internodes smooth and shining. Racemes three to eight more or less digitately arranged on the tip of the peduncle, purplish in colour. Spikelets in pairs of one sessile and other pedicelled flowers. The lower glume of the sessile spikelet has one deep pit on the back, about the middle of the glume. The sessile spikelet is awned, the pedicelled without awn or pits.

The grass strongly resembles *Dichanthium annulatum* from which it can be distinguished by the presence of pits on the lower glume of the spikelet.

A very common species and esteemed as a good fodder both for grazing or for stacking.

Heteropogon contortus Roem. and Schult. Spear grass Local names: *Kumeria, parwa,*

A perennial grass. Culms densely tufted up to 1. 5 m, tall erect or decumbent below, leafy mainly at the base. Leaves up to 60 cm. long and 3 to 7 mm,

wide, firm, linear. Often hairy from bulbous bases; racemes terminal, erect or bent 3.7 to 7.5 cm. long, very prominent from the dark brown awns which are jointly twisted to form a straight bundle especially in older racemes. Sessile spikelet about 7 mm. long almost hidden by the imbricate pedicelled spikelet. Awns 5 to 12 cm. long, usually twisted.

Themeda triandra Forsk.

A perennial grass with erect or ascending culms 2 to 2.5 m. tall. Leaves very narrow, scaberulous. with a few white hairs at the base. Ligule 1 to 1.1 mm. long, rounded, truncate, reddish, minutely haired. Inflorescence leafy and gently bent turning red when ripe. Bract leaf with a row of tubercle-based hairs on each side below the margin.

This is a characteristic grass of the meadow areas of the Himalayas, and is reputed to be a good fodder. Other species of *Themeda* (*T. arundinacea* Ridley, *T. caudata* Dur. et Jack, *T. quadrivalvis* O. Ktze and *T. anathera* Hack.) are found growing gregariously in the Terai area but these are not good fodder species.

Sorghum halepense Pers. Local names : *Baru, Banchari*

A perennial grass with long creeping rhizomatous rootstock. Culms up to 2.5 m. tall ; nodes minutely silky. Leaves 30 to 60 cm. long, 2 to 5 cm. wide, linear lanceolate, glabrous, margins rough; sheath glabrous, smooth. Ligule short, hairy at the back. Inflorescence a decompound panicle, 15 to 45 cm. long, pyramidal in shape and of varying shades of brown in colour. Branches of panicle ascending or horizontal. Rachis nearly smooth. Spikelets in groups. Sessile spikelets 4 to 5 mm. long, ovoid-lanceolate, compressed on one side, green or purplish. Pedicelled spikelets as long as the sessile but narrower.

The grass is believed to be a good fodder and suitable for hay-making if cut when 1 m. high.

Saccharum munja Roxb. (new name—*S. bengalense*) Local name : *Munj*

A tall tufted grass. Culms up to 6 m. solid, smooth. Base of culms very leafy. Leaf blades glaucous, flat, tapering from the base, upper leaves 20 to 60 cm. long, 5 to 10 mm. wide ; lower leaves up to 2 m. long and 20 mm. wide, scabrid on margin ; ligule a truncate membranous rim, minutely hairy on the back. Inflorescence a plumose panicle, 30 to 90 cm. long, lanceolate to cylindrical in shape,

Plate XLV

Heteropogon contortus

Photo: I. A. R. I.

usually dark reddish-purple in colour. Fruiting panicle oblong, branches appressed to the axis, white or greyish white. Spikelets in pairs of one pedicelled and one sessile on the ultimate branchlets, awnlets, lanceolate, up to 5 mm. long. Spikelets similar, one-flowered, and bisexual.

This is not a good fodder grass, but yields a valuable fibre for making baskets, mats and ropes. The leaves are largely used for thatching.

Narenga porphyrocoma (Hance) Bor Local names : *Kamal, ganeria*

A perennial grass with 2 to 2.5 m. tall slender, rounded culms. Leaf blades narrowed at base, flat, glabrous above, hairy and scabrid below, 30 to 60 cm. long, up to 6 mm. wide, midrib prominent, margins very scabrid, sheaths often a little shorter than internodes, very rough, glabrous or hairy throughout. Inflorescence a dense panicle, almost linear in shape, 30 to 45 cm. long, common axis vigorous, bearded at nodes; woolly, purplish. Sessile spikelets oblong brown 2.5 to 3 mm. long.

This grass is not considered of any value as fodder.

Sporobolus diander Beauv. Local name : *Chiria-ki-dana*

Annual or perennial; culms 25 to 80 cm. tall, smooth, glabrous. Leaves narrow 15 to 25 cm. long, 2 to 3 cm. wide, margin entire ; sheaths smooth, ribbed; ligule a rim of hairs. Inflorescence a panicle 10 to 80 cm. long, narrowly pyramidal, spreading outwards when mature. Branches naked at the base and bearing racemosely arranged, crowded minute spikelets at their apices. Spikelets spindle-shaped 1.5 mm.long, one-flowered ; grain sub-truncate.

Good fodder grass for cattle.

Vetiveria zizanioides Nash Local name : *Panni*

A densely tufted perennial grass with a branching rootstock and aromatic roots. Culms vigorous, up to 1.5 m. tall, smooth and glabrous. Sheaths compressed. Leaves 30 to 90 cm. long, 4 to 20 mm. broad, usually glabrous, pale green. Panicle oblong, erect, over 30 cm. long. Branches whorled, ascending, bearing racemes of spikelets towards the tip. Spikelets reddish-brown or purplish.

The grass is considered a fair fodder when young, but becomes coarse and fibrous during flowering.

Apluda mutica L. Syn. *Apluda varia* Hack.

Local names : *Bhanjura, tachula*

A perennial grass with a glaucous appearance. Culms up to 2. 5 m. tall,

solid, cylindrical, smooth and glabrous, branches flexuous. Leaf sheaths cylindrical, often thinly hairy; blades 10 to 35 cm. long, base narrowed or usually petioled, upper leaves small, ligule membranous, short rounded. Inflorescence a leafy panicle made up of very many solitary, simple racemes or false spikes terminating the stem and its branches each enclosed in a peduncled spathe. Spikelets in threes ; one sessile, two pedicelled. Sessile spikelets bisexual, terminal pedicelled spikelet male.

In Uttar Pradesh this grass is chopped and added to give bulk with more palatable grasses.

Cultivated Legumes

Lucerne

As the literature on this crop is already voluminous, these notes will refer only briefly to some aspects of its cultivation in India. Although de Candolle noted that *Medicago sativa* grows wild in Kashmir, apparently as an indigenous plant, there is little evidence of the plant being grown as a crop beyond a century and a half ago. There is no Sanskrit name for the plant. Lucerne as a cultivated crop may have entered India from the north-west. Although it may be and is grown in all parts of India, by enlightened farmers and on State Farms, its chief concentration as a routine farm crop is in the Punjab and the Western Districts of Uttar Pradesh.

Two varieties (Nos. 8 and 9) have been produced at the Fodder Research Station, Sirsa, Punjab. These have very similar characteristics and grow well throughout the Punjab on all types of soils, although they are best adapted to medium soils. No. 8 is a more vigorous type with somewhat broader leaflets, while those of No 9 are more elongated with toothed margins. No. 8 has violet flowers, those of No. 9 are bluish purple. The two varieties are similar in yield, giving 1,000 maunds of green fodder in eight cuts during the year. The seeds are yellow and kidney shaped. Both types are good for green fodder, but are said to be not so suitable for silage or hay. In India, the crop generally lasts for some four to six years under irrigated conditions, perhaps because of the type of management and cutting procedures.

There is evidence of the value of inoculation in India. Mann (1921) found that yields are improved by the application of soil (at a rate of 300 lb. per acre)

PLATE XLVI

Setaria glauca (Bandri), a good fodder grass which has a strong liking for moist soils and often invades paddy fields and becomes a pest. Terai area, Uttar Pradesh

Photo : D. Chatterjee

from a field in which the crop had already been growing vigorously. In Surat (Bombay State) inoculation increased the yield by 25 per cent and more than doubled the net profit. Inoculation plus liming had good results in Orissa.

Lucerne is generally sown in the Punjab from mid-October to mid-November, either by the bed system or in ridge and furrow. The bed system consists of sowing the crop on flat beds, two feet wide with irrigation channels one foot wide between the beds; these act as drains during the monsoon, and help to maintain adequate aeration of soil. Seeds are broadcast at 12 to 16 lb. per acre.

In the ridge system, the land is cleaned, well ploughed and manured as in the bed system and ridges are then made 22 to 28 inches apart. Seed is sown at 10 lb. per acre in grooves on top of the ridges; this system is more applicable to heavier soils.

Although the crop is generally grown under irrigation, it may also be established under dry-land conditions; if there is sufficient moisture in the sub-soil and if the soil is of a good type and well-drained, a remunerative yield can be obtained throughout the winter and early summer. There are indications that dry-land lucerne is higher in dry-matter content, grows longer into the heat of summer, and is less affected by the monsoon than irrigated lucerne, which may then become sickly and cease growth. Adequate and timely applications of organic manures and chemical fertilizers are of course essential for good and sustained yields.

The more important weeds and parasites of lucerne in India include *Cynodon dactylon*, *Cyperus rotundus*, *Saccharum spontaneum* and dodder (*Cuscuta* sp.). Lucerne aphis (*Chairophorus mazulatus*) and root rot (*Rhizoctonia* spp.) are also important.

The lucerne stand is rarely grazed in India, except occasionally when the crop is badly attacked by pests or diseases. The green fodder is considered to be good horse feed, but to be unsuitable for cattle or sheep without an adequate supplement of dry feed because of the danger of tympanitis or hoven.

Lander (1949) found that lucerne cut before flowering has 3.2 per cent of digestible protein and 14.7 per cent of total digestible nutrients; it is moderately high in calcium, poor in phosphorus, and high in carotene.

Berseem

Berseem (*Trifolium alexandrinum*). an annual white-flowered clover, is a native of the Eastern Mediterranean countries, being particularly widespread in cultivation in Egypt, Israel, Cyprus and Syria. It is especially important in the agriculture of Egypt, as it makes possible the maintenance of fertility and a constant succession of crops under conditions of intensive irrigated farming. The high yield per acre of Egyptian cotton is said to be due primarily to the after-effects of this legume. The livestock are dependent on it, particularly during the winter season from November to January (Henderson, 1918).

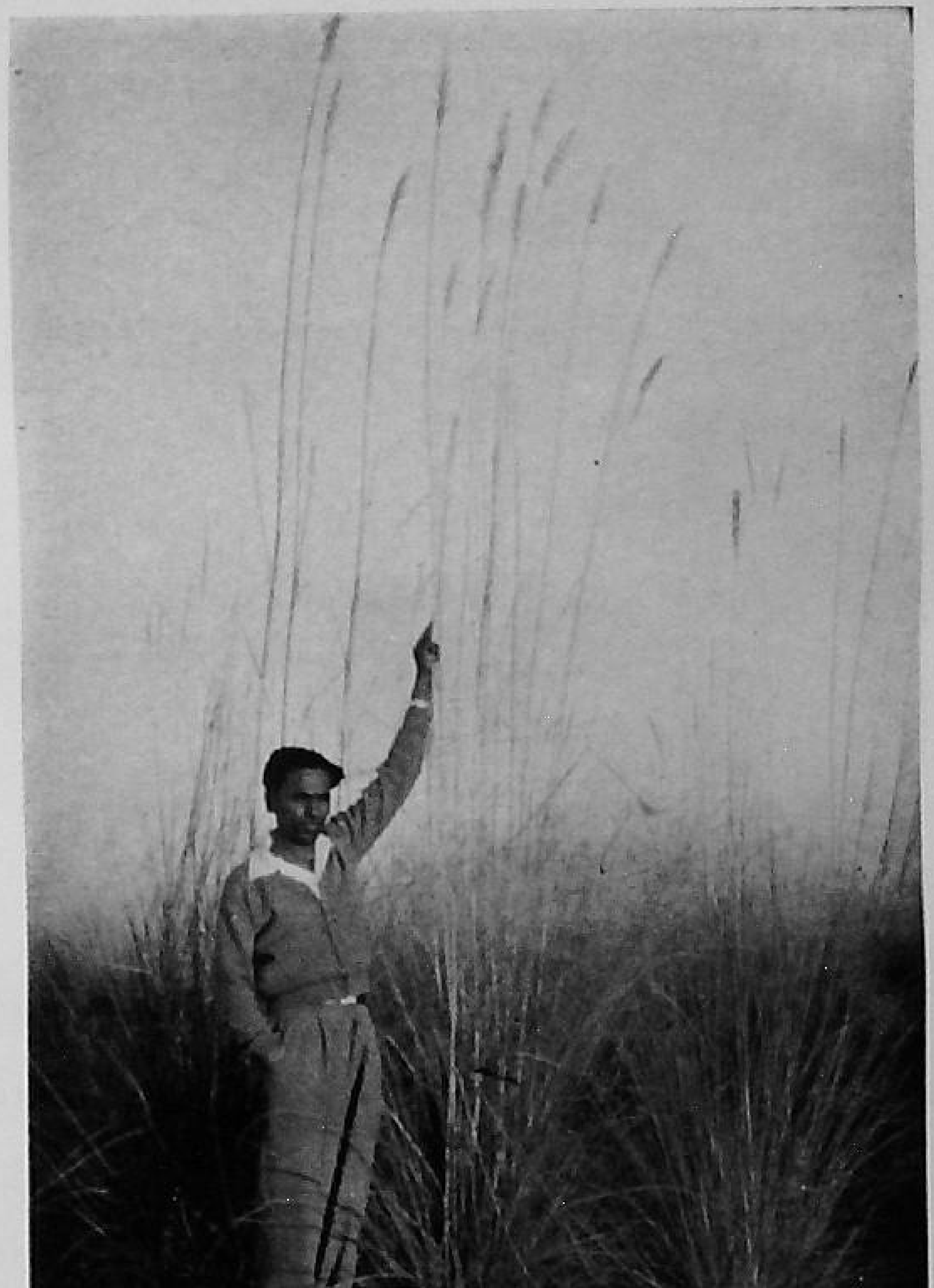
It was first introduced into Sind (now Pakistan) from Egypt in 1904 and spread from there to the Punjab. It also became an important crop in the North-West Frontier Province; this region was an important source of seed for British India. The two varieties, Fahli and Meskawi, have flourished in these new conditions, and are now cultivated in the northern parts of India, where irrigation facilities and cool winter weather are both available.

In India, berseem is a multi-purpose cold-weather plant, being useful as winter fodder (and for feeding green or for conservation as hay or silage), as green manure (though considered inferior to *Crotalaria* and *Sesbania*), and for reclaiming alkaline land. It gives four to seven cuts per season between December and May, and yields about 1,000 maunds per acre per season. During the cold weather in December and January, its growth is checked and again in May the high temperatures have an adverse effect on growth. Russell (1937) noted striking results from the cultivation of berseem in rotation with cotton in Sind (now Pakistan); it can be sown in cotton just after the last picking and has the important advantage in this Province of being useful in the reclamation of alkaline land.

In the Indian Union, berseem is an important crop in the Punjab and the western districts of Uttar Pradesh. It has also been grown successfully in Bihar, Madhya Pradesh, Madras and Mysore but is considered inferior to lucerne in Bombay State. It has not been successful in Assam, Bengal, Orissa, Cochin and Coorg.

Berseem has spread in the Punjab mostly at the expense of *senji* (*Melilotus parviflora*) and to some extent of *shaftal* (*Trifolium resupinatum*). The Meskawi variety is the most popular among farmers. There are now more than 100,000

PLATE XLVII



Saccharum bengalense=*S. munja*, (19 per cent) in association with *Desmostachya bipinnata* (81 per cent)

Photo : ICAR Grassland Survey Team

acres under the crop in East Punjab, particularly in canal-irrigated tracts. Berseem cultivation is also spreading in those western parts of Uttar Pradesh which have similar conditions. Although found to be adapted to the Chhota Nagpur plateau of South Bihar, the extension of its cultivation has been limited by lack of available land.

Henderson (1918) has described the common rotations followed in Egypt. In the north, cotton is followed by berseem in the first year; when several cuttings have been taken, a seed crop is obtained in May of the second year. Maize and sorghum are then grown as summer crops, after which the land is ploughed and put back to berseem. The legume gives several cuts and is then ploughed under during March prior to the sowing of cotton. The same rotation, berseem/sorghum/cotton, is followed in Sind. Roberts and Kartar Singh (1947) and Saini (1937) have noted that berseem can be grown continuously on the same land in the Punjab, but it usually occupies the cold-weather season following cotton. It can be grown in rotation with most crops except sugarcane.

In Egypt, berseem is often sown among standing cotton before the last picking (Henderson, 1918); a heavy watering is given and the seed is broadcast in standing water two inches deep at 40 lb. per acre. In this system of intercropping, the first cut of berseem is removed with the cotton stalks. This is a cheap method, and has the added advantage that the cotton plants will shelter the young berseem in hot weather. To avoid having a hard top soil under the cotton, it requires to be broken up before the berseem is sown.

In the Punjab, the crop is sown in standing cotton or maize, presumably again for protection. As it does well in Uttar Pradesh when broadcast in early paddy stubble, such land can be double cropped (*dofasli*). The legume seed is broadcast in paddy fields after an irrigation. It germinates readily in the protection of the paddy crop; when this is removed light irrigation will probably be needed. In this way, three to four cuts can be obtained at little cost apart from the seed. When berseem is not sown under a cover crop, a fine seed bed is prepared by thorough ploughing, clearing of weeds and levelling. In Uttar Pradesh, land is ploughed twice during the rains or immediately after the *kharif* crops have been cleared; four more ploughings are given to provide a good tilth.

Unless berseem is sown in a field in which this clover or *T. resupinatum* has been grown, inoculation is necessary. This may be done by bringing in soil at the

rate of two to four maunds per acre from an already infected area, or by the more modern technique of seed inoculation. Most agricultural chemists, particularly in Punjab and Uttar Pradesh, can supply the necessary inoculum. The culture is mixed with about half a seer of 10 per cent sugar or *gur* solution, and is sprinkled over the seeds; these are mixed thoroughly, dried in the shade, and then mixed with an equal quantity of moist earth before being sown. Protection in shade during drying, and sowing in the evening or on a cloudy day prevents the direct sunlight from damaging the culture; the inoculated seeds should not be kept for more than 24 hours. Seed inoculation should be done after the usual soaking of seeds for 12 to 24 hours.

Berseem is sown at an appropriate date between September and December, to avoid early excessive heat and later excessive cold. In North Sind, it is too hot to sow until early November. In Punjab, sowing continues from mid-September to mid-November. In Uttar Pradesh, sowings are made in October and November. In the Punjab, seeds are sown on ploughed land which has been irrigated to a depth of three inches; this is followed by harrowing and planking. Berseem is also sown on a dry seedbed and subsequently harrowed and watered. Soaked seeds are also sown on a fine moist seedbed and then lightly harrowed and planked; this makes it possible to postpone the first irrigation. Seeds must not be covered by more than half an inch of soil. Seed rates vary from 40 lb. per acre in Egypt to 16 to 20 lb. in the Punjab and 20 lb. in Uttar Pradesh. As the yield of the first cut is rather low, the berseem seeds are frequently sown in mixtures with *senji* (*Melilotus parviflora*), oats or rape. Seed rates are 10 to 12 lb. of berseem with 40 to 50 lb. of *senji* or oats.

Satisfactory germination is assured by light irrigation seven to ten days after sowing. Thereafter, irrigations are given as required; two or three may be adequate in the winter months, but the interval may be reduced to ten or fourteen days in April and May. The crop is also irrigated after each cutting. Frequent irrigation of seed crops is necessary during flowering and seed formation.

Berseem grows best on a rich loam. Where the soil is poor, well-rotted farmyard manure or compost may be applied at 150 to 200 maunds per acre. Organic manuring seems to have an effect on the multiplication of the nodule bacteria, and may ensure the success of uninoculated crop

PLATE XLVIII

Cenchrus ciliaris (Delhi strain)

Photo : I. A. R. I

Experiments at the Indian Agricultural Research Institute have shown the beneficial effect of phosphatic manuring of the legume on the yields of succeeding wheat crops. Different doses of phosphate alone and in combination with nitrogen and potash were applied to the berseem in the rotation: berseem/fallow/wheat/fallow/wheat. The best fodder yields of berseem were obtained with 64 lb. P_2O_5 per acre whether applied as superphosphate or farmyard manure or a combination of the two.

The young seedlings of berseem grow rapidly. The first growth is a single stem with numerous leaves but no lateral branches. When the plants are nine to twelve inches high, three or four side-shoots may have appeared. The first cut should then be taken. After this, there is profuse tillering and formation of side-shoots, so that the second cut is much bulkier than the first. The sooner the first cut is taken the better. Yields per cut in India vary from 400 to 1,000 maunds per acre from three to seven cuts, Roberts and Kartar Singh quote 500 to 600 maunds per acre as the average yield of green fodder in the Punjab.

The production of seed requires care if clean good quality seed is to be obtained. Plots reserved for seed should preferably be in areas protected from hot winds, and should be free from weeds such as chicory, dodder and mustard. Seeds are produced in the compact thickest inflorescences which retain the seed well. A seed crop should be sown at three times the usual seed rate. Less water is required for a seed crop than for a fodder crop. Suitable pollinating agents should be encouraged. The seed stand needs to be irrigated frequently during flowering and seed setting. Seeds ripen in May or June and yields may be adversely affected by hot winds at that time. An acre should produce three to five maunds of plump, bright yellow, clean seed.

There is a close relationship between yield and quality of seed, frequency of cutting, and date of last cutting for fodder. Experiments at Indian Agricultural Research Institute (I. A. R. I., 1951) showed that the maximum yield of seed was obtained by closing the area after a third cut taken in February. At Lyallpur, Roberts and Kartar Singh found a similar relationship between date of last cut and the percentage of yellow, red and brown seeds (with 80, 50 and 25 per cent germination respectively).

TABLE CIX

Relationship between date of cutting and yield of seeds

Number of cuts for fodde	Yield per acre of seeds	Percentage germination of seeds	Percentage proportion of :		
			Yellow	Red	Brown
	Mds. — Srs				
None	4 — 29	91	78	17	5
One	3 — 12	82	72	20	8
Two	1 — 2	61	63	21	16
Three	0 — 36	29	38	30	32

It is concluded that it is not advisable to take more than one fodder cut if good seed of high germination are required.

Berseem is a very nutritive fodder with a protein content of up to 23 per cent. It therefore makes economy in concentrates possible, and can be fed to working bullocks, or to dairy animals without tainting the milk. Since high-protein berseem is unbalanced in carbohydrates, it is advisable to supply these in the form of roughages such as *bhusa*, chopped *juar* or *kadbi* at 30 to 40 lb. per head per day. There is little danger of bloat after the first cut, and then only while the animals are getting used to the new feed. Tympanitis may usually be traced to admixture with *senji*.

Although berseem is usually cut, carted and fed green, it can also be pastured or conserved as hay or silage. When animals are tethered on the crop, the ground should be slightly moist but not soft enough to suffer from the trampling. The grazing livestock should be moved forward frequently by electric fencing or herding. Berseem should not be grazed when it is wet with dew.

The best season for haymaking in Uttar Pradesh is from February to April, when the weather is neither too cold or too hot; in the cold season it does not dry properly and in the hot the crop becomes excessively dry and brittle. The crop is cut and spread out uniformly in the field to dry. It is collected early in the morning while still damp with dew, and placed in small heaps in the fields. After

three to four days the crop is removed to a larger stack and allowed to ferment slightly, not enough to cause burning. The hay is then baled or stacked; good hay should be of a golden colour, with minimum loss of leaf. Its protein content will, of course, depend on the time of cutting and method of curing, but is likely to be around 14 to 16 per cent. The hay is high in calcium and phosphorus.

Berseem will add up to 300 lb. of available nitrogen per acre to the soil (Henderson, 1918). After alkaline land has been reclaimed to the stage at which it will grow rice, berseem can then be introduced into the crop sequence to prepare the land for cotton. Berseem is less tolerant of alkali than *Sesbania aculeata* (*dhaincha*). Berseem supplies high protein fodder when other fodder crops such as lucerne are not available. It competes better with weeds than lucerne. Berseem is superior in yield and quality to shaftal and *senji*.

The encouragement of seed production is dependent on the price of fodder. There are no public or private organizations concerned with the provision of high quality seeds in adequate quantities and at attractive prices, and accompanied by the essential inoculum. The absence of adequate inoculation may be affecting a further extension of the acreage under this valuable leguminous fodder crop.

Berseem Cultivation in Egypt

Nayer Farid (1953) has supplied some particulars of cultivation practices, yields and varieties in Egypt, which has such a large acreage in the Nile valley and delta under this crop.

Because the seeds are small, a fine and firm seed-bed is essential. The seeds are broadcast at 20 kg. per feddan (—4200 m.^{2}) on heavily irrigated level land from late September to the last week of October according to weather conditions. Superphosphate is broadcast at 100 kg. per feddan before the second watering (before the first cut). The crop requires twelve waterings during the season, i. e. two or three between each cut according to the soil and weather.

The Meskawi variety is cut four times for fodder and the last cut is left for seed. Times of cuttings are :

1st 60 days after sowing

2nd 40 days later

3rd 40 days later

4th 35 days later

About seven tons per feddan of green fodder can be obtained from each cut, or a total per season of 25 to 30 tons per feddan.

Blooming begins from the second week of May and ends in the second half of June, according to date of sowing and weather. The seed crop begins to mature at the end of June. Seed yields vary from 150 to 350 kg. per feddan according to climate and soil; little seed can be obtained in an excessively hot and dry climate.

The Egyptian varieties are as follows :

Meskawi : tillers well and gives four cuts per season.

Saidi : gives tillers and branches, but only two cuts per season and a poor yield.

Fahli : a vigorous plant, branching only, giving only one cut either for green fodder or for seed.

Table CIX shows the chemical composition and nutritive value of berseem, according to analyses made at the Chemical Section of the Experiment Station at Giza of material harvested at the Station.

TABLE CX

Berseem in Egypt : Chemical composition, total digestible nutrients, starch equivalent and nutritive ratio

Cuts	Crude Nutrients Per Cent						Digestible Nutrients Per Cent				Value Number		
	Moisture	Crude	Ether extract	Ash	Soluble carbohydrate	Crude fibre	Crude protein	Ether extract	Soluble carbohydrate	Crude fibre	Starch equivalent per 100 lb.	Total digestible nutrients. (T. D. N.)	Nutritive ratio 1 :
Ist	88.28	2.33	0.17	2.06	4.67	2.49	1,8	0,1	3,7	1.5	6.3	7,2	3.0
nd	85.15	2.60	0.18	2.28	5.91	3.88	2.0	0.1	4.7	2.2	7.8	9.1	3.5
3rd	80.53	2.77	0.26	2.52	7.81	6.11	2.0	0,1	6.0	3.5	9.6	11,8	4.8

Senji

The main advantage of *Senji* (*Melilotus parviflora*) over other legumes is its lower water requirement. *Senji* is an old *rabi* crop of Punjab and Western Districts of Uttar Pradesh, but is being steadily replaced by berseem. An improved strain F.O. No. 1, has been evolved in the Punjab, with a higher yield and more uniform stand and growth. *Senji* may be grown either as a mixed crop with barley or oats, or as an under-crop in *kharif* crops such as cotton or maize, or in rotations such as the following examples from the Punjab (Roberts and Kartar Singh, 1947).

Maize/*senji*/sugarcane/wheat or cotton.

Maize/*senji*/wheat.

Cotton/*senji*/wheat/*toria*.

Senji is a nutritive fodder, but cattle have to become accustomed to its unpleasant taste. There is a tendency to cause bloat or colic depending on the stage of maturity at which the green crop is cut.

Methi

Trigonella foenum-graecum is grown as a winter fodder in the Punjab, where it is considered superior to *senji*, and more drought-resistant than *senji* and other fodder legumes. *Methi* is grown as a mixed or undercrop, as a spring catch crop after sugarcane, and as the main *rabi* crop. The main October-sown crop is ready for harvesting in February/March, while the January crop is ready in April. The main crop generally yields one cut of 200 to 250 maunds of green fodder per acre.

Shaftal

Although *Trifolium resupinatum* withstands grazing better than the other annual legumes of Northern India, and is adapted to colder and more hilly regions, in the plains it is steadily losing ground to berseem.

Pillipesara

Phaseolus trilobus is a quick growing creeping legume which has come into prominence as a multi-purpose crop, particularly in the paddy tracts of

PLATE XLIX

Mucuna cochinchinensis (velvet bean)
Photo : I. A. R. I.

Madras. Sampson (1936) suggests that it may be a wild form of *Ph. aconitifolius* but noted that it grows wild in many parts of India, e.g. Assam, Bombay, Madras and Punjab.

The cultivation of this plant is largely confined to India, where, more particularly in Peninsular India, it has acquired greater importance as soil cover and green manure than as fodder. The crop is mostly raised as a pure crop in wet paddy lands after the paddy has been harvested, The duration of the crop is about 120 to 140 days. By adjusting the date of sowing, it is possible to obtain green fodder for many months in the year.

Guar *or cluster been*

This is a hardy, erect short-duration annual legume well-known for its low water requirements and adaptability to light soils. Until recently, it has been called *Cyamopsis psoralioides* D.C., but the alternative name *C. tetragonoloba* is now proposed ; throughout this book the first name has been used. The crop probably originated in India but is not found in the wild state. Two related species of less importance are *C. senegalensis* and *C.stenophylla*.

Guar is a herb with a single stem with few branches, growing to a height of six to eleven feet. There are several varieties in India distinguished mainly by habit and height of plant and by size and shape of their leaflets. The crop may be grown almost throughout India, for grain, vegetable, green manure or green fodder. It is frequently grown in mixtures with other crops such as cereals, oilseeds and other grain crops; also mixed with *juar* or *moth* as a *kharif* fodder in Northern and Western India. *Guar* plays an important role as a *kharif* crop in rotations preceding wheat or other *rabi* crops. The crop comes into bearing two to three and a half months after sowing; it is usually harvested in September/October in Northern India, but this may be extended up to February in North-East and Southern India, depending on the way in which the crop is to be utilized.

Guar is a nutritious fodder when fed green; it is best cut when in flower or when pods are beginning to form, when it will be low in fibre, have a high nutritive value and be palatable to livestock. The yield of green fodder is about 125 maunds per acre non-irrigated, double that on irrigated land. Green *guar* fodder is lower in protein and fat, but non-fibrous than most leguminous fodders. It is comparatively low in phosphorus but has sufficient calcium. The crop can be made into

silage and hay: the grains are valuable as livestock feed and are used in place of cottonseed.

Khesari

Khesari (*Lathyrus sativus*) is a hardy annual legume, easily cultivated as a garden or field crop in poorer soils and in situations unsuitable for crops, and yields a cheap but low-grade pulse which is used for food by poorer classes of people. The crop is also grown for fodder and green manure. It is cultivated as a *rabi* crop throughout Northern India, in Bombay, Bihar, Madhya Pradesh and Uttar Pradesh. Although not an important crop from an all-India point of view, since it comprises only about nine per cent of the total area under pulses, *khesari* is nonetheless important in Bihar (one-third of the total pulse production), Madhya Pradesh and West Bengal (a fifth of their pulse production). In recent years, however, acreage and production have both fallen considerably. A number of different strains have been produced in Bihar, Madhya Pradesh and Bombay.

The fodder is considered to have a high nutritive value.

Cowpea

Vigna sinensis is an annual sub-erect legume with succulent glabrous twining stems, generally found in the form of a spreading bush about three feet high. Leaves are pinnately trifoliolate, with long petioles carrying large ovate-acute dark green leaves. Flowers are large, in racemes, yellowish or reddish in colour according to variety. Pods are rounded, thin, two to 24 inches long, slightly constricted between the seeds, varying in colour, but usually straw-coloured when ripe. Seeds ten to fifteen in number, of varied size, shape and colour, closely resemble the common kidney bean, *Phaseolus vulgaris.*

The cowpea has the following vernacular names in various parts of India : *lobia, barbati, bora, rawan, alsande.* It is a quick-growing, multi-purpose legume which can fit well in crop rotations. The cowpea is a major pulse crop only in certain regions such as the high monsoon tracts of the South-west, where is grown for grain or as a green vegetable. It is grown for grain as a concentrate for livestock or as a forage crop in the Punjab, or as a green manure in Assam and West Bengal. Varieties suitable for these purposes have been evolved in the different regions.

The Punjab selection Fo. S. No. 1 is a half-bushy and vined fodder type which matures its first pods in 170 days. It has characteristic seeds rhomboidal in shape, densely and uniformly covered with minute blue specks giving them a slaty blue colour. Nos. 2 and 7 are improved seed types. Gamnie has listed nine varieties in Bombay varying in pod length and seed colour. Four improved varieties have been evolved in Madras:

C. 5s, grain-cum-fodder type of 85 days duration.

C. 419, vegetable type of 160 days duration, with 18 inch long light green fleshy pods,

C. 322, fodder type of about 125 days duration, and

C. 421, grain type of 95 days duration, with buff-coloured grains.

Similarly, four vegetable types have been evolved in Travancore-Cochin :

EB. 1 early, with 24 inch long white pods,

EB. 2 early, with 18 inch long red pods,

EB. 3 medium with 10 inch long scarlet pods, and

EB. 4 late, with 12 inch long white pods.

The cultivation of the cowpea may in some parts of the world extend up to 40°N provided the summer months are sufficiently warm. It is indeterminate in growth, growing in all seasons except the winter in sub-tropical India. It is not demanding as to soil type. The cowpea is grown as a monsoon crop in coconut gardens in Malabar, or on upland rice fields in summer in Mysore and elsewhere. It is, however, usually grown as a mixed crop with *ragi* in Malabar and Mysore, with *juar* in Andhra, Mysore and Tamilnad, or with maize or *juar* in the Punjab.

The crop is sown from March to July, broadcast at 40 to 50 lb. per acre, or dropped behind the plough at 29 to 30 lb. per acre, or in rows 12 to 18 inches apart at 10 to 20 lb. per acre. Generally 20 to 30 lb. per acre is required when sown for fodder, half that rate when sown for seed. The seeds germinate readily and will have sprouted well by the third day after sowing. Flowers appear in six weeks from sowing, and green pods are ready for picking in another 2 weeks; the crop continues to fruit irregularly over a period, and ripe pods will be ready for harvest in three months in the early varieties and in five months in the later varieties.

When grown alone, one expects to obtain about 40 or 50 times the quantity of seeds sown, or about five to seven maunds per acre; in mixed cropping not more than two maunds of grain per acre are obtained. An average green fodder yield is about 200 to 350 maunds per acre.

Kudzu

The Kudzu vine (*Pueraria hirsuta* syn. *P. thunbergiana*) was first introduced in 1925 at the Imperial Agricultural Research Institute, Pusa, Bihar, in connection with studies on nodules. Its potential value in soil conservation led to a revival in interest in the early forties, but the absence of floweriug and seed setting hampered the extension of its propagation. The factors responsible were studied first at Poona and later, since 1945, at the Indian Agricultural Research Institute. Boshi Sen has also done much to popularize the plant in the hilly country around Almora, U. P.

Pueraria hirsuta is adapted to practically all parts of the country, while tropical kudzu (*P. phaseoloides*) is adapted more particularly to tropical India and is winter-killed in the north. The ideal place for greater use of *P. hirsuta* is in the riverine tracts of the Gangetic Plain (Dabadghao, and Gandhi, 1952)

As seed is rarely produced in Delhi until the plants are three years old, kudzu is normally propagated vegetatively by crowns. These are dug from the field during December and January, when the plant is dormant due to low temperatures. Crowns have been supplied from the Indian Agricultural Research Institute at Re. 1/- per dozen excluding transport; a few thousand can be supplied each year and can stand a transport period of over ten days

The plant sheds its leaves in winter, thus adding much organic matter to the soil. New growth commences in the spring, and the plant remains green during the hot months even without irrigation ; water is required only for early establishment.

PLATE L

Kudzu at the Indian Agricultural Research Institute, Pusa, New Delhi

Photo : D. Chatterjee

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GLOSSARY OF INDIAN TERMS

aghnya	"That which shall not be killed" (cow)
ahir	class of cattle owners common in Uttar Pradesh and Madhya Pradesh
alsande	*Vigna sinensis*
Amritmahal	cattle breed from Mysore State
anjan	*Cenchrus ciliaris* and *Hardwickia binata*
anna	16 annas = 1 rupee
arhar	*Cajanus cajan*
aus	early season, first crop sown in April-May
avare	*Lablab niger*
babul	*Acacia arabica*
Baiga	tribe in Central India
bajra	*Pennisetum typhoideum*
Bakarwal	nomad tribe; goat keeper in Kashmir; breed of thin-tailed coarse-wooled sheep from Kashmir
banchari	*Sorghum halepense*
Ban-Gujjar	nomadic shepherd in northern India
barani	dry or rainfed cultivation; also refers to dry lands
barbada	*Indigofera glandulosa*
barbati	*Vigna sinensis, Vigna unguiculata*
barajergi	*Dichanthium annulatum*
baru	*Sorghum halepense*
barwari	*Panicum antidotale*
bathan	cattle shed
battai	tenure system based upon share cropping in northern India
ber	*Ziziphus jujuba*

bersim	*Trifolium alexandrinum*
bhanjura	*Apluda mutica*
Bhariya-Gond	tribe in central India
bher	*Ischaemum rugosum*
Bothia	tribe coming from Bhutan
Bhumiya	land owner in Rajasthan
bhusa	residue after threshing, in particular of wheat and pulses
bir	grassland used for hay-making
bora	*Vigna sinensis*
bund	ridge, small dam
bundhies	small bunds
bur	*Cymbopogon schoenanthus*
chaoli	*Vigna sinensis*
chaor	grassy clearing in forests
chari	*Sorghum vulgare*
charwa	*Cenchrus ciliaris*
cheena	*Panicum miliaceum*
chhimbar	*Eleusine flagellifera*
chhoti jergi	*Bothriochloa pertusa*
chil	*Pinus roxburghii*
chir pine	*Pinus roxburghii*
chiriya-ka-dana	*Sporobolus diander*
cholam	*Sorghum vulgare*
chota marvel	*Dichanthium annulatum*
chuni	ground pulses for animal feeding
curra	*Setaria italica*
crore	10,000,000

daihan	cattle camp in a forest (Madhya Pradesh)
daihan cattle	cattle resorting to daihans
dofasli	double cropping
deswali	local or country
dhaincha	*Sesbania aculeata*
dhak	*Butea monosperma*
dhar	ridge or spur in higher altitudes used generally for summer grazing in the Western Himalayas
dodda jolah	*Sorghum vulgare*
dub	*Cynodon dactylon*
Fasli year	1st July to 30th June
fulgavat	*Themeda cymbaria* (and other *Themeda* spp.)
gaddies	shepherds in Kashmir ; also name of Kashmir hill type sheep and goats
gair mumkin	uncultivable land
ganeria	*Narenga porphyrocoma*
gaucher	grazing ground
ghala	mixture of bran and husks of legume seeds (Rajasthan)
ghamar	*Panicum antidotale*
ghee	clarified butter of cow, buffalo and even camel's milk
ghuned	*Anthistiria ciliata*
gingelly	*Sesamum indicum*
Gir	cattle breed from the hills and forests in Saurashtra State
git	*Panicum antidotale*
Gond-Baiga	tribe in Central India
goria	*Chrysopogon montanus*
Go Sadan	cattle camp

Goshala, Gowshala	charitable institutions where cattle are maintained
gowadi	cow camp
gram	*Cicer arietinum*
gram, Bengal	*Cicer arietinum*
gram, black	*Phaseolus mungo*
gram, cow	*Vigna unguiculata*
gram, green	*Phaseolus aureus*
gram, horse	*Dolichos uniflorus*
guar	*Cyamopsis tetragonolobus*
Gujjar	nomadic shepherd or cattle keeper in the Uttar Pradesh hills
gur	jaggery or unrefined sugar
guria	*Chrysopogon montanus*
Hallikar	cattle breed from Mysore State
Hariana	cattle breed from East Punjab, India
Hassan	sheep breed, also buffalo breed from Mysore
Hissar	cattle breed similar to Hariana
Jafrabadi	buffalo breed from Kathiawar
jaggery	unrefined sugar
Jagir	large estate given by the king
jaman	*Syzygium cumini*
Jamnapyari	goat breed from Uttar Pradesh
jarewa	*Bothriochloa pertusa*
jarga	*Dichanthium annulatum*
Jat	farmer from Rajasthan, Punjab or Uttar Pradesh
Jaunsari	tribe from the hill portion of Dehra Dun district
jonna	*Sorghum vulgare*

juar	*Sorghum vulgare*
kachkuri	*Mucuna pruriens*
kadbi	stalks of sorghum
kail	*Pinus excelsa*
kalai	all pulses, especially *Phaseolus* spp.
kamal	*Narenga porphyrocoma*
kancha	grazing system in Andhra forests
kander	*Bothriochloa odorata*
Kangayam	cattle breed from Coimbatore District, Madras State
kankar	hard layer of calcium carbonate in the soil; also refers to calcium nodules
Kankrej	cattle breed from North Gujerat, Bombay State
kans	*Saccharum spontaneum*
kantiara	*Carthamus oxyacantha*
kartak	*Dichanthium caricosum*
katcha pit	uncemented pit silo
kaval	protected area
khair	*Acacia catechu*
Khanabadosh	nomads ; hence non-holders of grazing rights
khatik	professional butchers, especially Hindu
kharif	monsoon crop season : June to October
khel	*Dichanthium caricosum*
kher	*Acacia catechu*
khesari	*Lathyrus sativus*
kolinji	*Tephrosia purpurea*
kolukattai	*Cenchrus ciliaris*
Korba	tribe in Uttar Pradesh

korra	*Setaria italica*
Kothi	residential house of a rich man; also a granary
kulthi	*Dolichos uniflorus*
umeria	*Heteropogon contortus*
Kumbar	a potter who owns no livestock
kura	bran
kuran	grasslands in Madhya Pradesh and Bombay States used for hay making
kusal	*Heteropogon contortus*
kutcha	temporary, as opposed to permanent
lakh	100,000
obia	*Vigna sinensis*
mahua	*Madhuca latifolia*
maidan	open stretch of grassland
makchari	*Euchlaena mexicana*
malguzar	big landowner who collects rent from tenants
Maria	aboriginal tribe in Madhya Pradesh
marua	*Eleusine coracana*
marvel	*Dichanthium annulatum*
masel	*Iseilema laxum*
mash	*Phaseolus mungo*
massar	*Lens esculenta*
masur	*Lens esculenta*
matar	*Pisum sativum*
maund	82 lb.
Mehesana, Mehsana	buffalo breed from North Gujrat
methi	*Trigonella foenum-graecum*

mhota marvel	*Dichanthium caricosum*
moshi	*Iseilema wightii*
moth	*Phaseolus aconitifolius*
mukhiya	used primarily for the headman of a village
mung	*Phaseolus aureus*
munger rains	pre-monsoon rains
munj	*Saccharum bengalense*
mur jhains	*Eremopogon foveolatus*
Murrah	buffalo breed from Delhi and Punjab
musel	*Iseilema laxum*
mushi	*Iseilema wightii*
mutter	*Pisum sativum*
nais	cattle camp in forests in Saurashtra
Nili	buffalo breed from the Punjab
nimb	*Azadirachta indica*
Nistar land	land set apart to meet the bonafide domestic and agricultural needs of the people
nullah	a natural drain
Ongole	cattle breed from Andhra State
palwan	*Dichanthium annulatum* ; *Andropogon pertusus* ; *Bothriochloa pertusa*
Panchayat	village committee
pandhar phali	*Indigofera linifolia*
panni	*Vetiveria zizanioides*
Pargana	a division of a district
parwa	*Heteropogon contortus*
patada shevra	*Desmodium diffusum*

patta	document showing the ownership of land
pattadar	landowner
pattagar	local dignitary who owns a large extent of land (Southern India)
pavna	*Sehima nervosum* ; *Ischaemum laxum*
penta	subdivision of a tehsil
phanta	*Opuntia* spp.
phul	*Pseudanthistiria heteroclita* ; *Themeda triandra* ; *Themeda cymbaria*
pillipesara	*Phaseolus trilobus*
pinjrapole	a charitable institution for the protection of all kinds of livestock
pivali godhadi	*Heylandia latibrosa*
popat	*Lablab niger*
Rabari	nomad tribe ; professional cattle breeders in North Gujerat, also camel breeders in Rajasthan
rabi	winter crop season : October to March
ragi	*Eleusine coracana*
raus	hill stream
rawan	*Vigna sinensis*
rawat	sub-caste of Rajputs
reh	alkaline soil
rohida	*Eulalia argentea*
rumna	fodder reserve
rupee	1 rupee=approx. 1/6d.
ryot	tenant
ryotwari area	area where the cultivator pays the land revenue directly to the State

sag	any leafy vegetable used for food ; *Spinacia oleracea ; Tectona grandis ; Terminalia belerica*
Sahiwal	cattle breed from Montgomery District, Punjab, Pakistan
sal	*Shorea robusta*
samai	*Panicum miliare*
sanai	*Crotalaria juncea*
sandhaur	*Bothriochloa intermedia*
santal	tribe in Madhya Pradesh
sawai	share-cropping system
sawana	grasslands at lower altitudes in the Western Himalayas
sawandar	holder of proprietory grazing rights in sawanas
seer	40 seers=1 maund
senji	*Melilotus parviflora*
shaftal	*Trifolium resupinatum*
shata	*Iseilema laxum*
sheda	*Sehima nervosum*
sheesham	*Dalbergia sissoo*
shevra	*Alysicarpus rugosus*
shola	temperate evergreen type of forest in the Nilgiris
simul	*Salmalia malabarica*
Sindhi	cattle breed from Karachi and Hyderabad districts, Pakistan
sissoo	*Dalbergia sissoo*
suckal	*Sehima nervosum*
Surti	buffalo breed from Bombay; also goat breed from Bombay
taccavi	loans for agricultural purposes given by the Government
tachula	*Apluda aristata; Apluda mutica*
taluk	subdivision of a district, same as tehsil

taungya	a form of shifting cultivation. A Burmese system in which close the cultivator is allowed to grow crops for 2 years in forest land; he is then asked to plant forest species in rows and may continue his cultivation between the rows until the seedlings are fully established. The cultivator neither pays for cultivation nor is paid by the Forest Department.
tehsil	sub-division of a district
teora	*Lathyrus sativus*
Thakar	local dignitary among Rajputs; a term of respect
Tharparkar	cattle breed from Sind, Pakistan
thatch	grass plot
tika	hamlet; sub-division of a village; a unit of management for village grazing in Kangra (Punjab)
tikhadi	*Cymbopogon martini*
til	*Sesamum indicum*
tirni	grazing dues in parts of Rajasthan
toon	*Cedrela toona*
toria	*Brassica campestris* var. *toria*
tur	*Cajanus cajan*
urid	*Phaseolus mungo*
usar areas	areas with alkaline soils
val	*Lablab niger*
vidi	grasslands in Saurashtra used for hay-making
zaid	season between rabi and kharif: March to June
zamindar	big land owner who pays land revenue to the Government and also collects land rents from his tenants. This system is being gradually abolished.

INDEX OF GENERA AND SPECIES

It has unfortunately not been possible in many cases to give the most recently accepted botanical names of genera and species. In most cases, the name given by the author of the original publication has been adopted. It is hoped that this Monograph will be followed by another by Dr N. L. Bor on the grasses of India, and that the present confusion in the nomenclature of Indian grasses will be overcome.

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